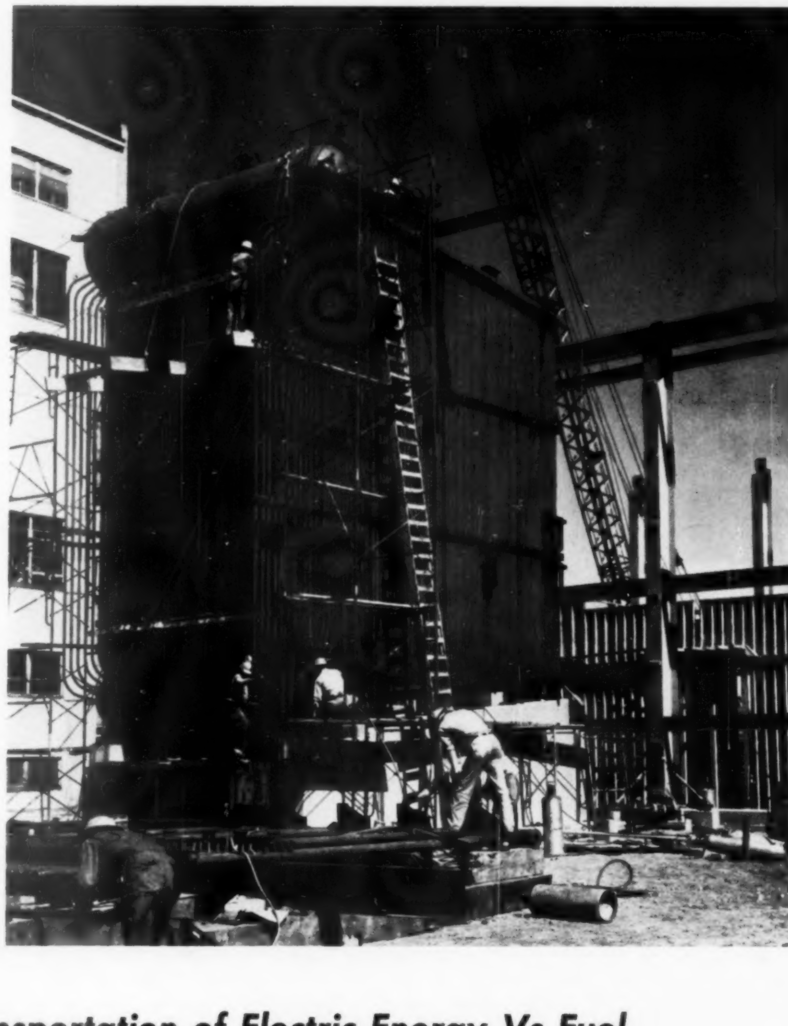
Combustion

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION



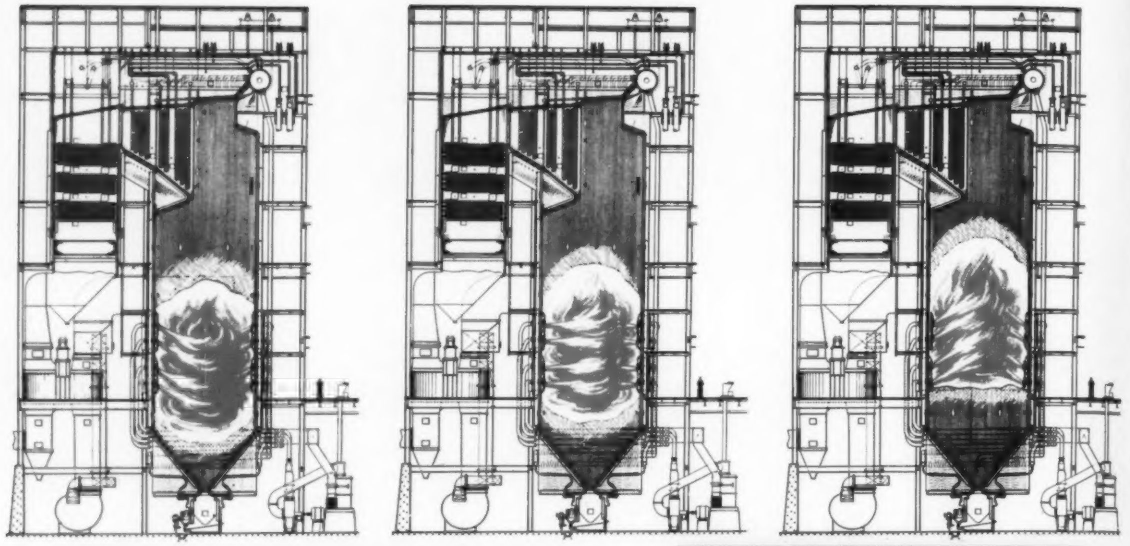
vember 1961

Transportation of Electric Energy Vs Fuel

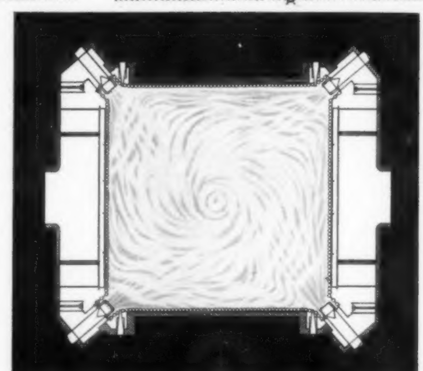
Turbine By-Pass

Record Power Plant Completion

Engineers Society Water Conference



HOW C-E TILTING TANGENTIAL BURNERS CONTROL SUPERHEAT.
First diagram shows burners tilted downward to reduce furnace outlet temperature. Middle diagram shows normal operating position. Third diagram shows upward tilt to send higher temperature gases to superheater.



Plan view of tangentially fired furnace shows how action of fuel and air streams sets up extreme turbulence for thorough mixing and complete combustion.

C-E TANGENTIALLY FIRED BOILERS

give more complete combustion... most sensitive steam temperature control

Tangential firing – pioneered by Combustion in 1927 – is today the most widely accepted method of firing pulverized coal, gas or oil, separately or together, in large utility boilers. Air and fuel are fed to the furnace in a number of relatively small streams which are directed from each of the four corners of the furnace.

This assures intimate mixing and sets up a strong turbulent motion within the furnace . . . to produce the most complete combustion with minimum carbon loss. The combustion gases fill the furnace for more rapid heat transfer to the waterwalls.

The tilting nozzles of C-E Tangential Burners automatically tilt up or down as steam temperature varies. If steam temperature goes too high, the nozzles tilt downward . . . more furnace wall surface becomes effective . . . gas temperature to superheat surface is lowered . . . steam temperature goes down. Or, if steam temperature drops, the nozzles tilt upward . . . hotter gases go to the superheater . . . steam temperature goes up.

Catalog PC-8 gives full information on tangentially fired C-E boilers, including units with capacities as low as 70,000 lb of steam per hour. Write for your copy today.

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ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS

Combustion

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

volume 33 number 5 **November 1961**

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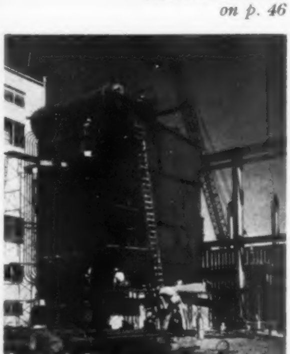
COVER PHOTO

Construction view of the boiler unit for the 22 Mw plant described in detail on p. 46



Transportation of Electrical Energy vs. Transportation of Fuel . . . 30

W. E. Hopkins

The utility industry in its never ending search for better, more economical ways of doing business are now thinking about fuel availabilities at the power plant which means transportation costs as well as raw material charges.

A New Arrangement for a Steam Turbine By-Pass . . . 38

J. B. Prather and J. H. Potter

Close matching of steam and metal temperatures as an aid to quick startups has led many to take a sharp look at by-pass arrangements. Here is one for a 150 Mw, 2400 psi, 1000 F, 1000 F unit.

Steam Power Plant Clinic . . . 42

Igor J. Karassik

The author opens his discussion of where best to get feedwater for reheat attemperation by quoting "Progress is made by solving problems resulting from the making of progress." With this as a background several solutions are offered.

Record Completion Time for 22 Mw Power Plant . . . 46

D. N. Higgins

A lapsed time of seven months from confirmation of contract to completed plant promises an interesting story. The author fills in the details.

Twenty Second Annual International Water Conference . . . 51

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EASTERN OFFERS MORE THAN COAL

Coal buyers who look for the most for their fuel dollar know that a given coal has certain specific characteristics. They also know that the full value of the coal depends on the organization that produces it. Such extras as on-time delivery, consistent adherence to contract specifications, ready assistance in solving a complex fuel problem . . . all these and many others are of even more importance. That's why Eastern Gas and Fuel Associates stress the "extras" that are a part of every ton of coal they sell.

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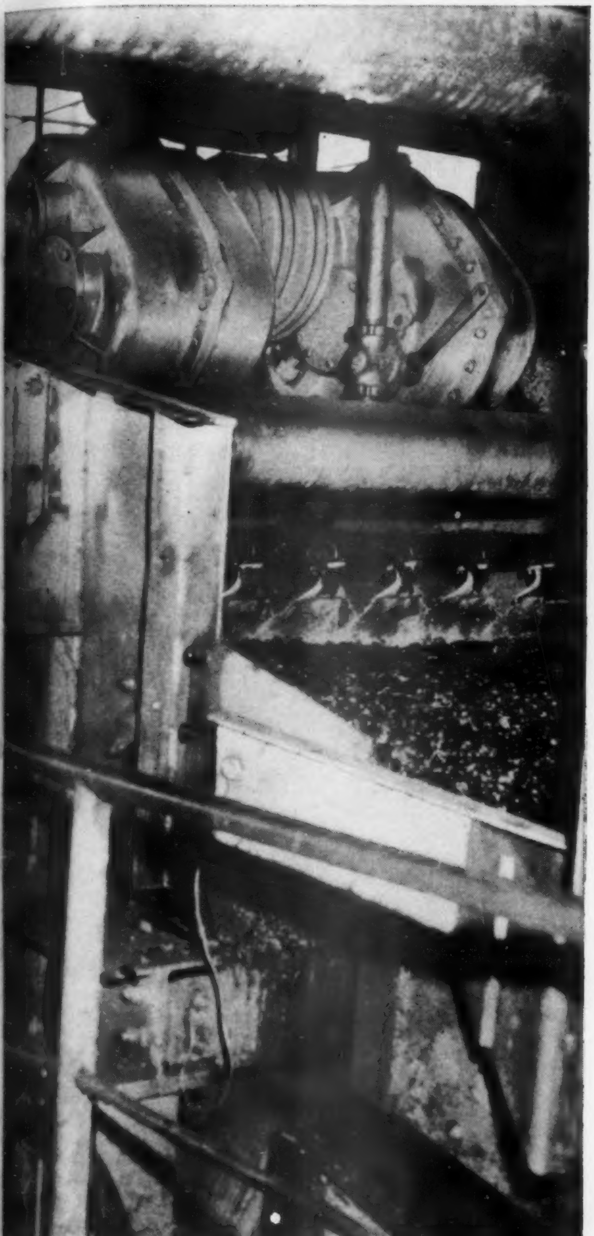

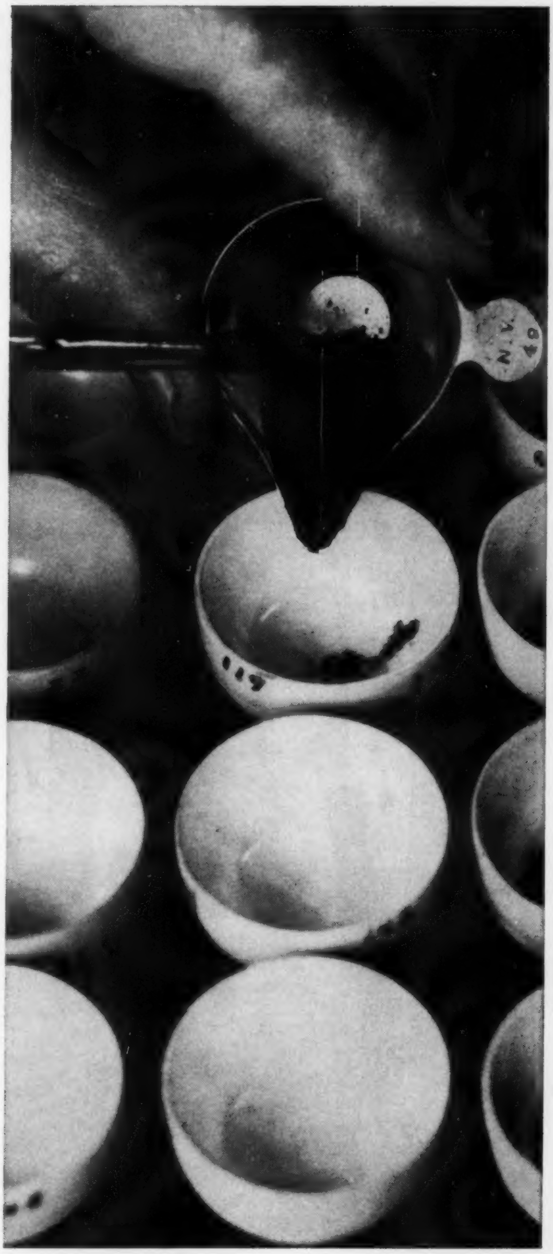

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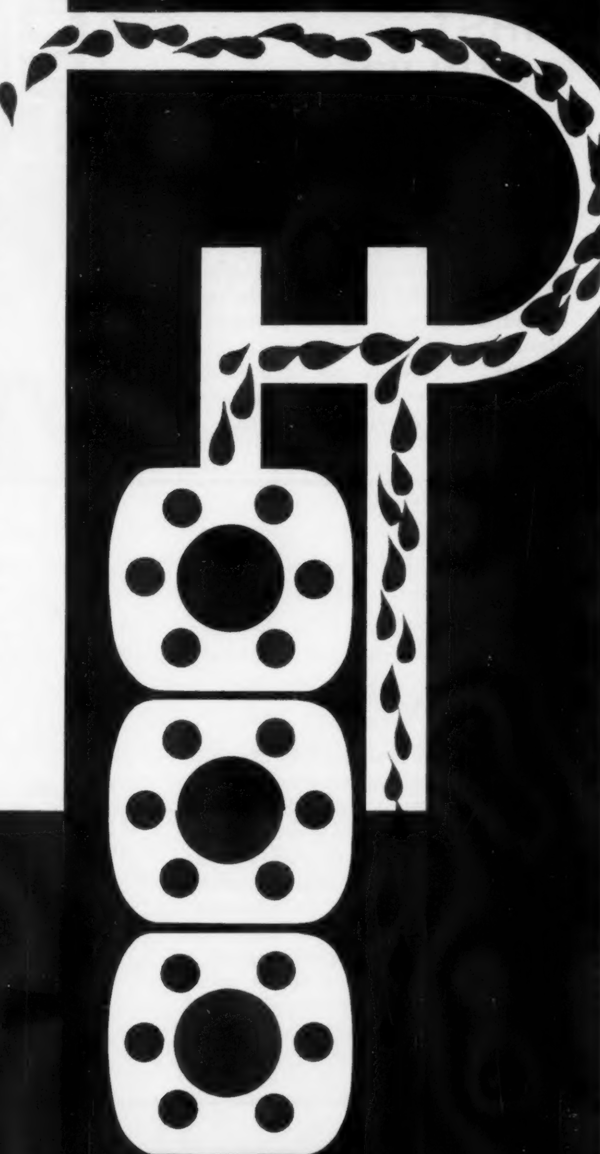
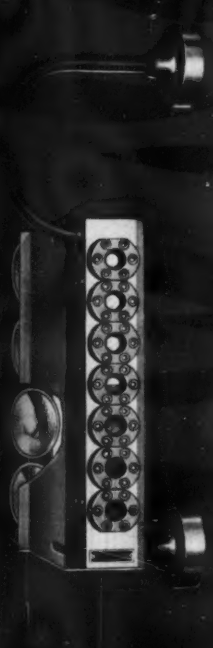
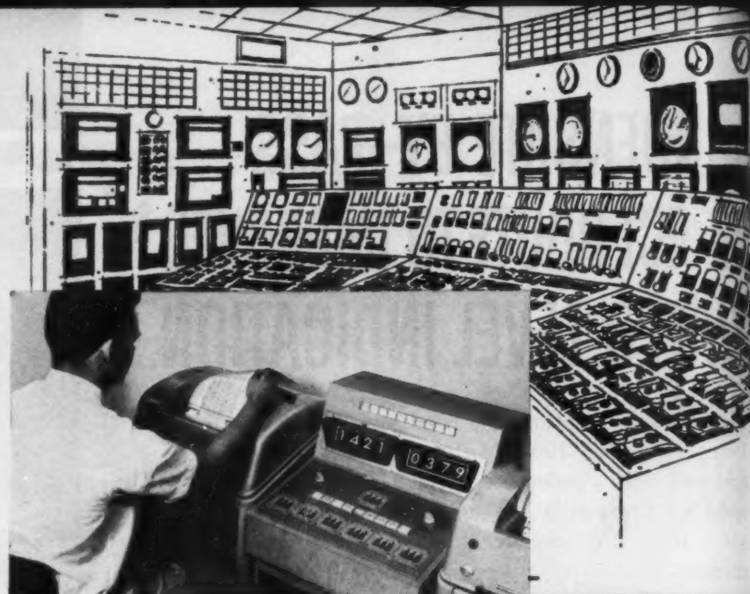




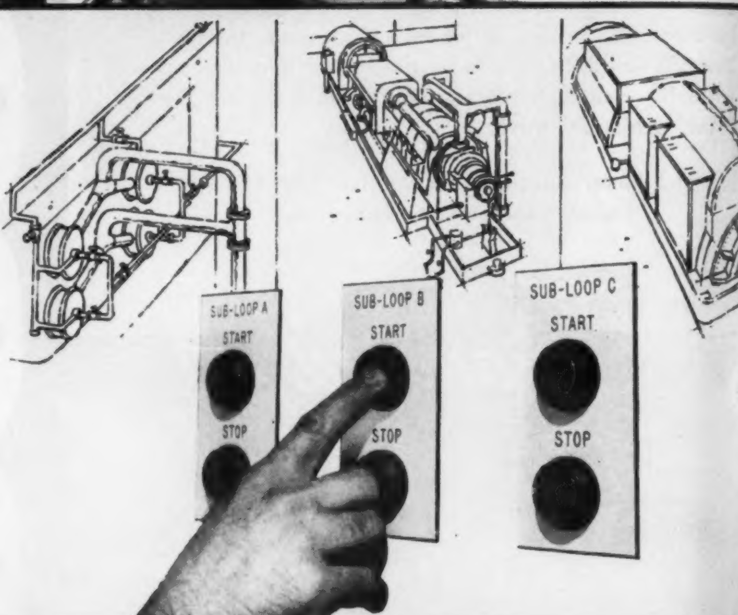
FIRST SIMPLIFY...

First step to automation is to *simplify* the information now presented by a multitude of multi-record charts, gages, and annunciator lights. The Bailey approach gives the operator data he needs (logged periodically), keeps continuous watch on all variables, makes calculations where required, alarms when trouble threatens. Reliability of recorded data is increased . . . operators can devote full attention to correcting off-normal conditions and improving operations.



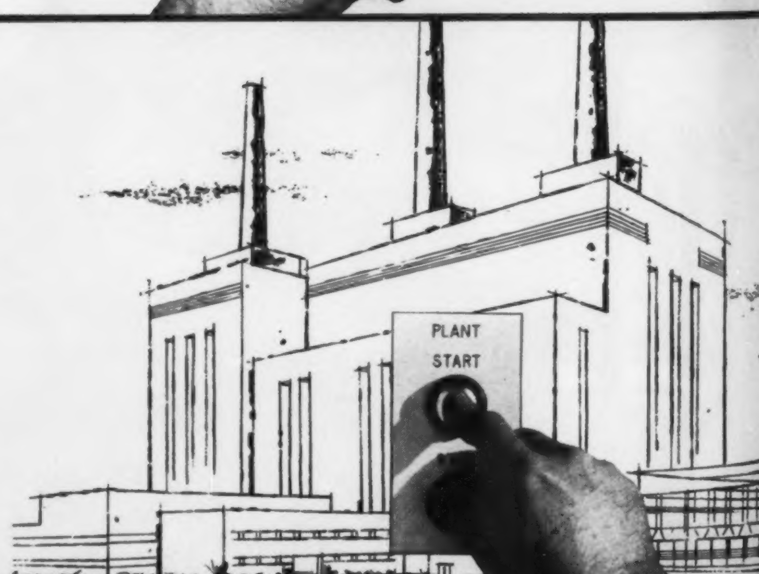
NEXT VERIFY...

Next, verify the practicability of automation by extending supervisory controls, letting equipment perform more operating functions. Automate key systems, one at a time, by push-button controlled sub-loops. This approach smooths the transition to complete automation and improves safety to men and machinery by providing safe, uniform start-up, shut-down, and normal operating procedures.



THEN AUTOMATE

Final steps to automation can then be made at any time with full confidence and proved operational experience. These steps are: 1) to consolidate supervisory controls, conventional controls, and sub-loops for full-range automatic operation once the plant has been placed on the line; and 2) ultimately, to add start-stop control to provide full automation.



How to get *assured results* from AUTOMATION

...and gain as you go

Complete automation is a long step forward — with many challenges along the way.

The Bailey step-by-step approach to automation makes possible step-by-step certainty ... provides step-by-step benefits ... requires only step-by-step commitment.

In the initial steps it makes possible many or most of the benefits of complete automation with considerably less investment than required for the ultimate. And it permits the decision to take each succeeding step to be made only after satisfactory evidence that it is economically justified and functionally sound.

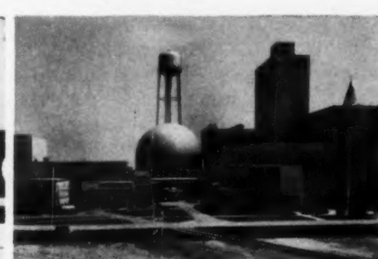
Bailey 700 Systems draw on the best available techniques, including analog and digital manipulation, trend recording, time sharing, scanning, alarming, calculating, controlling, and logging, as required to meet operating objectives. Individual systems, including logic and sequence units, are coordinated by Bailey's distinctive method of *parallel programming* to achieve plant automation. The parallel-programming approach improves plant availability by making it practical to remove individual systems from service or reprogram without disturbing operation.

Ask your Bailey District Office, or write for more information on the Bailey step-by-step approach to automation with Bailey 700 Systems. Bailey Meter Company, 1025 Ivanhoe Road, Cleveland 10, Ohio. In Canada —Bailey Meter Company Limited, Montreal.

Bailey Systems Concepts are Founded on 45 years of Experience

Twenty-one of the twenty-six most efficient steam-electric stations in the United States use Bailey Instruments and Controls.* This reflects more than 45 years of Bailey developments devoted to improving the reliability of power-plant operation. **Listed in Federal Power Commission Report S-143.*

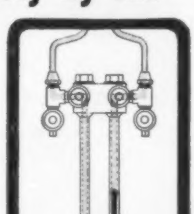
Bailey experience in automation dates from electrically operated boiler controls in 1924, automatic start of boiler controls on steam-electric locomotive in 1936, and fully automated package boilers in 1948. This Bailey 750 System for simplified display of power-plant operating information was installed in 1959.



Bailey experience extends to and includes the atomic power field. In the completion of the Enrico Fermi Atomic Power Plant at Monroe, Mich. in 1961, Bailey Meter Company was prime instrument contractor, supplying both pneumatic and transistorized electronic control systems. A165-2

BAILEY METER COMPANY

700 Systems



Abstracts From the Technical Press

(see p. 55)

Instruments and Controls

Automatic Boiler Control. Anon. *Fluid Handl.* 1961, (Apr.), 107–8.

By the introduction of automatic boiler controls on four Super-Economic boilers equipped with low ram stokers the thermal efficiency has been increased from an average of 71.76 to 75.21 per cent.

Combustion Analysis and its Application in the Automatic Control of Boiler Plant. P. D. McCormack. *S. Afr. Mech. Engr.* 1961, **10** (Feb.), 187–207.

A technique for determining the thermochemical parameters of importance to the efficient operation and control of furnaces burning hydrocarbons in air, is developed. It involves, in effect, a rapidly convergent successive approximation process which simultaneously determines both composition and temperature resulting from the chemical reaction. The parameters calculated are optimized ones corresponding to a balance between combustion efficiency and heat transfer (proportional to gas pressure). They include primary air/fuel ratio, flame temperature, excess air value, and flue gas composition.
C.E.G.B. Digest 1961, **13** (May 27), 1517.

Problems and Experience with Controls of Forced Flow Boilers. F. Jakob. *Mitt V.G.B.* No. 71 1961, (Apr.), 83–90 (in German).

After briefly outlining the reasons for the application of forced-flow boilers and the disadvantages of the Sulzer separator, controls for forced-flow boilers are discussed which produce rapid change of the boiler output at constant pressure and temperature as a function of turbine load. The control system for the two 450 t/h Benson boilers at Fortuna III power station is described. The points to be considered in further improvements of control systems for such boilers are discussed.

Nuclear Energy

Controlled Fusion Reactions. P. M. S. Blackett. *J. Brit. Nucl. Engng. Conf.* 1961, **6** (Apr.), 138–50.

The 47th Thomas Hawksley Lecture in which the present state of knowledge in the field and future prospects were discussed. The various steps along which research should proceed are outlined but an early realisation of controlled fusion reactions is not anticipated.

Compact Packaged Air Preheater being unloaded for installation on new 100,000 lb/hr boiler at Hoffmann-La Roche's Nutley, N. J. headquarters. In operation, it will increase the temperature of the combustion air 375°F—thereby increasing boiler efficiency by approximately 8%.

PACKAGED AIR PREHEATER

WILL RECOVER 330°F FROM NEW BOILER FOR HOFFMANN-LA ROCHE INCORPORATED

Hoffmann-La Roche, one of the leading producers of pharmaceuticals, vitamins and aromatic chemicals, specified a Ljungstrom Packaged Air Preheater for their new boiler for three reasons: 1) This compact, preassembled unit is ready to run as soon as it's connected to the power line and ducts—no extra installation or erection costs; 2) The unit occupies only about 450 cubic feet of space but will cut boiler exhaust temperatures from 680°F to 330°F—for about 8% saving in fuel; 3) Savings in fuel alone—roughly 1% for every 40°F drop in exit gas temperature—can pay for the unit in two short years!

Packaged Ljungstroms are available in sizes for use on boilers in the 25,000 to 250,000 lb/hr range—can give you these same fuel saving advantages. For full information, write today for our 14-page Packaged Air Preheater booklet.

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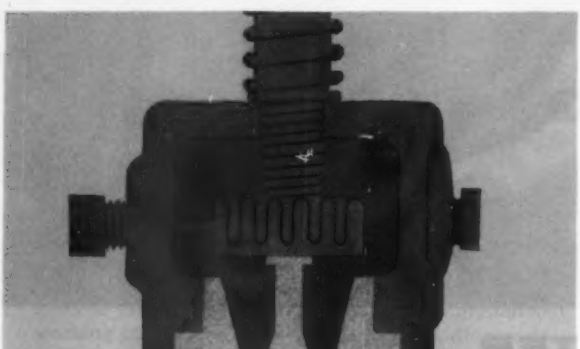
THE IK RETRACTABLE... NEW ASSURANCE OF BOILER CLEANING EFFICIENCY AND ECONOMY

For years . . . in thousands of boilers . . . the Diamond IK Long Retractable Blower . . . with its close-cleaning helix, positive rack-and-pinion drive and single motor . . . has provided maximum cleaning effectiveness at lowest possible cost. Now, thanks to seven new major design improvements, the IK assures even better performance. Examine them carefully and you'll soon see why.



1 Minimizes valve leakage problems . . . flexible valve arrangement. In most valves, differentials in valve body temperatures produce distortion which causes leakage. In the new IK valve, this problem has been solved. Critical valve internals expand and contract *with* temperature changes, thereby eliminating distortion and drastically reducing the possibility of costly leakage.

2 Ample coverage to clean the biggest boilers . . . box-type beam. For cleaning coverage over 34 feet, the Diamond IK Series 400 features a new box-type beam construction. This design retains the simplicity and convenience of two-point blower support with 6 inch trolley beam, yet assures ample strength and rigidity for stable, uniform lance travels to 42 feet and over. It also improves blower appearance and provides protection during installation. (Note: The evenly spaced roller marks on the retracted lance attest to the IK's exclusive "every inch" cleaning helix. It's your assurance of uniform, complete cleaning ... *regardless* of tube bank arrangement and tube spacing.)

Background: El Segundo Station of Southern California Edison Company. Foreground: Installation of Cooper-Bessemer Soot Blowing Compressors at El Segundo.

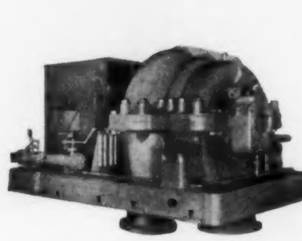
Dann Goodson, *Manager Motor-Driven Compressor Sales, The Cooper-Bessemer Corporation, explains...*

How soot blowing with air increases power plant efficiency

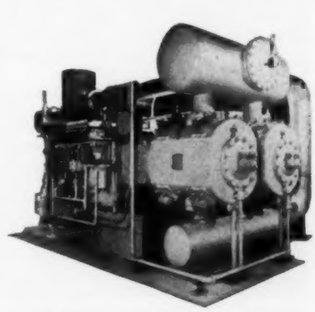
POWER PLANTS are switching from steam to compressed air for cleaning of furnaces and tube banks because they can *reduce costs.* The new way, with Cooper-Bessemer compressors, has these important advantages:

1. **Pressure is always adequate to do clean, thorough job.**
2. **Better programming with air... gets better cleaning results for higher boiler efficiency.**
3. **Lower initial cost, lower operating cost, and hence lower cost for blowing medium... less waste.**
4. **No quenching action on hot alloy tubes or pressure vessels.**
5. **Less maintenance of blower equipment due to erosion, corrosion, packing wear.**
6. **Improved housekeeping... no steam or condensate leakage.**
7. **Greater over-all economy of blowing medium on evaluated basis.**
8. **Eliminates condensate makeup required when blowing with steam.**

You can find out more about this by writing for a copy of the article reprint, "Steam or Air: Which costs more for boiler cleaning?" We would be glad to help you in planning your compressor facilities for soot blowing... or other power plant uses. Call the office near you.



Direct motor-driven multi-stage centrifugal compressor. Sizes of 3000 cfm free air and up.



Multi-stage reciprocating compressor. Sizes up to 30,000 cfm free air.

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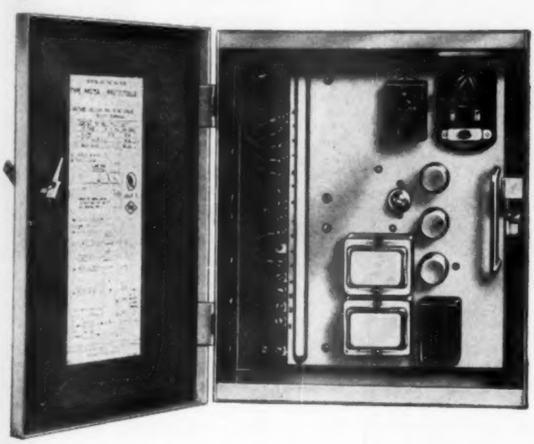
senses only the flame!

New Honeywell Protectoglo relay assures "maximum safety"

Available for use with the Ultra-Vision Flame Detector or with standard flame rods is Honeywell's famous R4075 Protectoglo* relay.

This new relay features "maximum-safety" self-checking which is particularly desirable for continuously burning industrial burners. A self-checking circuit checks the circuit and the components of the Protectoglo *once every second.*

The mounting cabinet of the Protectoglo has all-voltage terminals and a quick-disconnect control base that enables you to remove the relay without disconnecting any of the wiring. Plug-in components can easily be removed and replaced if necessary.



In addition, flame-rod assemblies are available to meet every industrial application. Alarm contacts can be powered from separate line or low-voltage circuit. And a special zinc dichromate finish resists the corrosive effects of most industrial atmospheres.

*Trademark

Honeywell protects Los Angeles' new $65,000,000 power plant

Los Angeles' Department of Power and Water installed the Honeywell Ultra-Vision Flame Detector and Protectoglo System to insure maximum flame safeguard protection for its new Scattergood Steam Plant. This huge power facility covers a 57-acre ocean front site south of the Playa del Rey district of Los Angeles.

The plant now uses two 91-foot-long turbine generators to produce 320,000 kilowatts of power. When the entire complement of six generators is put into operation, the anticipated output will be 1,200,000 kilowatts.

Gas, oil or a combination of both fire the Scattergood boilers. Gas consumption under full load is approximately 1,520,000 cubic feet per hour, and oil is used at 250 barrels an hour. Boilers are 133 feet high and furnace volume is 65,000 cubic feet.

For full information about Honeywell Flame Safeguard Control Systems, call your nearby Honeywell office. Or write Honeywell, Dept. CN-9-23, Minneapolis 8, Minnesota. In Canada, write Honeywell Controls, Limited, Toronto 17, Ontario.

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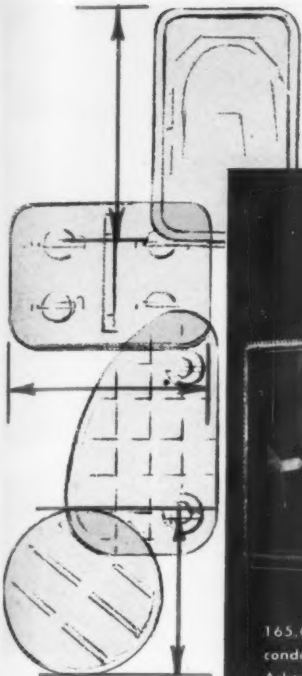

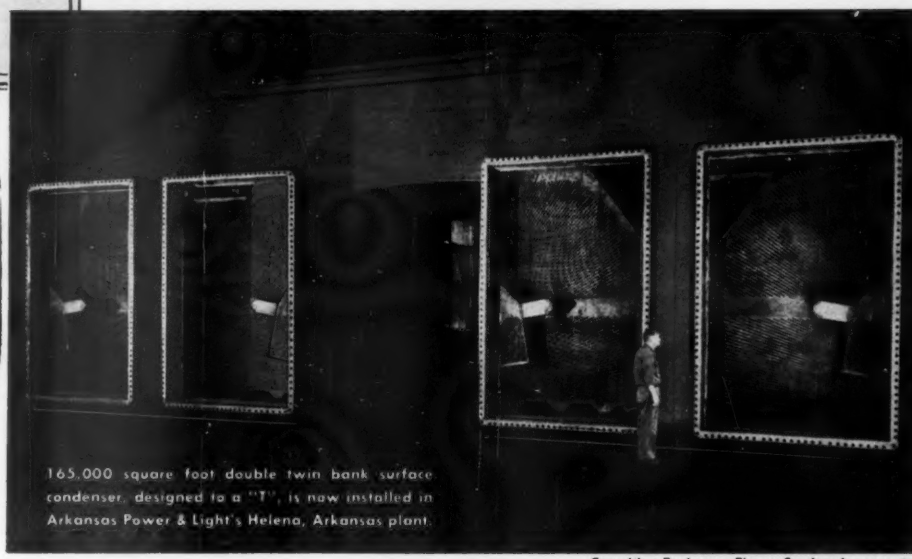

165,000 square foot double twin bank surface condenser, designed to a "T", is now installed in Arkansas Power & Light's Helena, Arkansas plant.

Consulting Engineers: Ebasco Services Incorporated

MOST VERSATILE TUBE BANK LAYOUT IN THE INDUSTRY

YUBA SURFACE CONDENSER DESIGN . . . most flexible . . . any size . . . any arrangement. Through design advances such as those incorporated in the unit above, Yuba illustrates the concepts you can expect from years of engineering leadership in the power industry.

Yuba's twin-bank tube layout, seen here in a two shell "T" type installation, promotes unobstructed, equally distributed flow. Through Yuba's patented design, the condensate can be deaerated with oxygen content guaranteed to be less than 0.005 cc per liter.

As a design extra, Yuba staggers the tube support plates – reducing harmonics – eliminating vibration. These are some of the reasons why Yuba surface condensers of all sizes have been installed in plants throughout the world. You'll want to know more about the most versatile tube bank layout in the industry – contact Yuba today.

Other Yuba products for steam power plants include feedwater heaters, evaporators, expansion joints, cranes, tanks, structural steel erection, and scores of other items.

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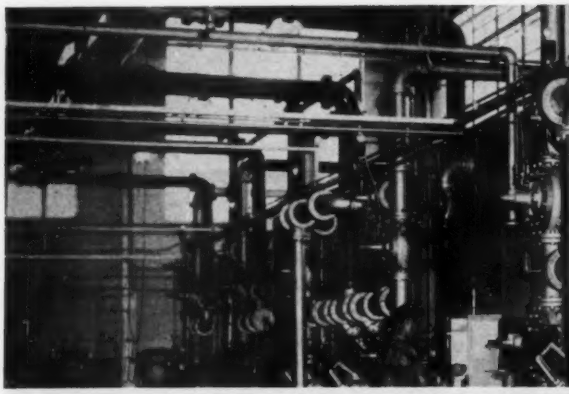
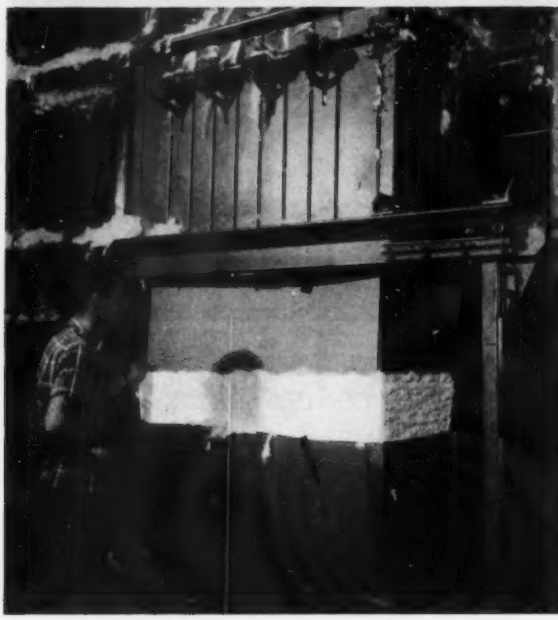
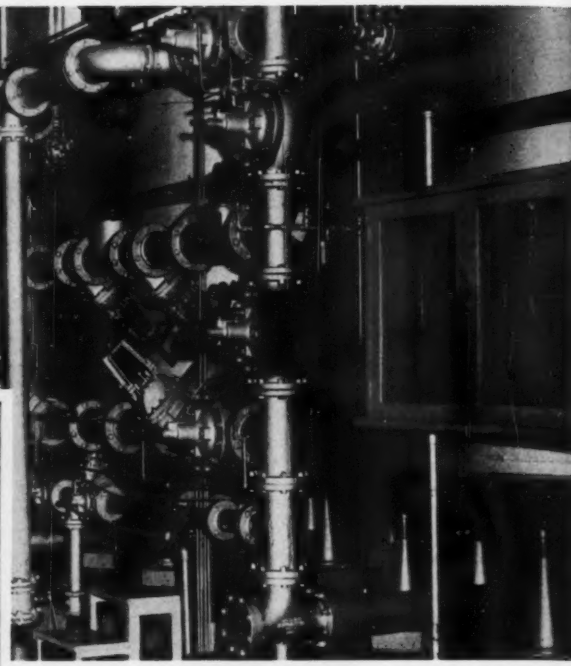






ABOVE: AMBERLITE® 200 is used in two softeners in this group. Here the durable polymeric structure of this resin successfully resists the action of "aggressive water" which shortens useful life of conventional ion exchange resins.

LEFT: Baling of rayon staple fiber at Lowland, Tenn., plant of American Enka Corporation.

Enka rayon plant solves "Aggressive Water" problem with AMBERLITE 200

At the Lowland, Tenn., plant of American Enka Corporation, water for washing rayon staple fiber and yarn is breakpoint chlorinated to oxidize impurities. It enters softeners with 0.3 ppm residual chlorine. Trace metals present in the raw water act as oxidation catalysts and make the chlorine "aggressive" toward ion exchange resins. Useful life of conventional cation resins is shortened through decrosslinking which weakens the polymer structure, increases pressure drop, and promotes channeling.

When AMBERLITE 200 was installed in two of American Enka's ion exchange units, its revolutionary polymeric structure was the answer to "aggressive water". Wherever oxidation is a problem, AMBERLITE 200 gives longer resin life than conventional resins, and thus lowers operating cost. AMBERLITE 200 also has excellent resistance to bead cracking from physical stresses.

For more information on AMBERLITE 200 performance under conditions that degrade conventional resins, write for our technical bulletins. Also ask for a 16-page booklet that shows how many different industries use AMBERLITE ion exchange resins for specific applications—boiler-water softening and deionizing, chemical processing, and many others.

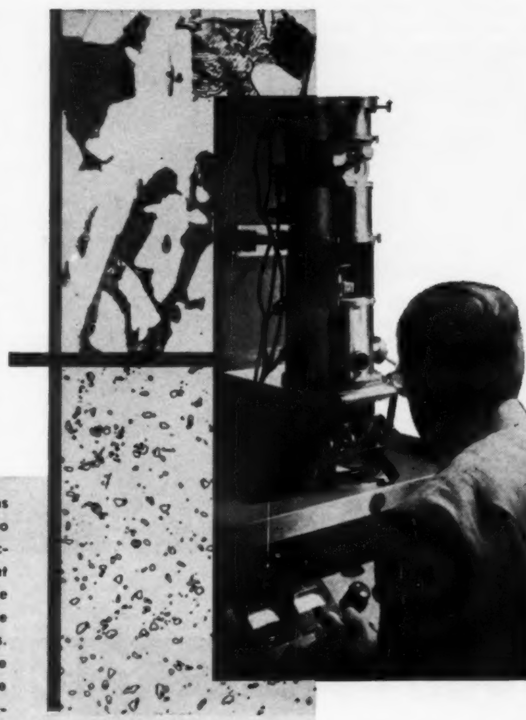
ROHM & HAAS
PHILADELPHIA 5, PA.

AMBERLITE 200

Nalco's Specialized Metallurgical Skills and Facilities Find Causes; Prevent Metal Failures

A ruptured boiler tube is a catastrophe wherever and whenever it occurs. The one shown above, sent to Nalco Laboratories for metallurgical analysis, revealed that prolonged overheating was the basic cause, with several contributing factors. Recommended changes in chemical treatment and operative procedures can help prevent recurrence.

Boiler metal failures are not a frequent occurrence in modern steam plants. But with thousands of operating boilers in service, failures do occur . . . enough of them to make necessary keeping Nalco's specialized metallurgical skills and facilities at work analyzing failures and their causes, with the continuing aim of developing "failure-proof" chemical treatment and control techniques.



Carefully selected, ground, polished, and etched steel specimens give up their secrets under metallographic microscopes at Nalco (right). At left top is a normal low-carbon steel boiler tube structure, showing the intermixed crystals of ferrite and pearlite at 500 magnifications. Below normal structure is a section of tube metal at the same magnification which has developed carbide spheroidization, indicating undesirably high metal temperatures. This change in structure occurs after prolonged heating in the range of 900° F. to 1350° F., and is a combined function of time and temperature—occurring very slowly at 900° F., but often requiring only a few hours to develop at 1350° F.

Nalco's accumulation of metallurgical research and experience may be helping to protect your boiler metal against failure right now. Nalco was first among water treatment organizations to recognize the importance of metallurgy and metallography in complete water treatment services . . . And first to install the facilities and experts to track down the frequently obscure causes of metal failure. Finding preventive measures, both chemical and physical, has been going on in the Nalco Laboratories for about 25 years.

Complete metallurgical analysis must take in the entire situation. At Nalco, such a complete investigation may include water analysis, gravimetric analysis, flame photometry, X-ray diffraction, electron microscopy, and electron diffraction and spectroscopy. To our knowledge, Nalco is the only water treatment organization capable of making such complete investigations in this highly specialized field. For further data on boiler metallurgy, write for free Nalco Bulletin 61, and Nalco Reprint 32. To obtain prompt consultation regarding water treatment problems, call your Nalco Representative.

NALCO CHEMICAL COMPANY

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Subsidiaries in England, Italy, Mexico, Spain, Venezuela and West Germany

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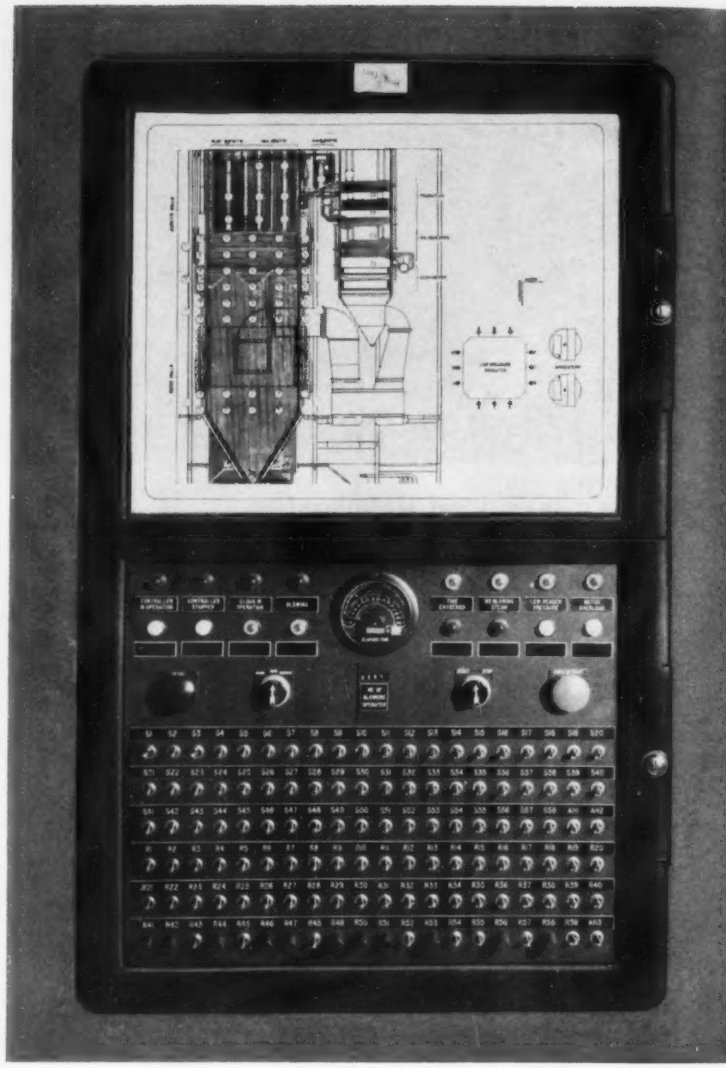
Nalco® ...**Serving Industry through Practical Applied Science**



Selective-Sequence Controller

Up to 120 electrically-driven long retractable Vulcan soot blowers can be controlled by this SSC-120 controller. With it the operator can monitor the complete blowing program and get an instant report should there be any malfunction. In such case, interlocks automatically stop the blowing until a correction is made.

Vulcan Selective-Sequence control offers the greatest flexibility in automatic soot blowing. It permits varying the sequence by individual blowers — at any time, and in any way found desirable to improve boiler cleaning or to save blowing medium. Tied to a built-in clock, it permits 24-hour scheduling with three or more sequences.

Vulcan Automatic-Sequential Control permits the operator to pre-select any number of units to be operated individually — not necessarily by zones or bands. Without leaving the panel he can revise the sequence at any time, or switch instantly to single-unit operation.

Both control systems are described in Bulletin 1029. Write for it.

With either system: A new console-mounted miniature panel provides even greater convenience and efficiency. Soot blowing may be tied to some such phase of boiler operation as steam temperature control, a refinement with which Vulcan has had more than six years of experience. And for the ultimate in soot blower control, the Vulcan system can be tied in with computer operation of the plant.

Vulcan "Automated" Soot Blowing

Modern boilers must be kept clean to operate efficiently—but the cleaning itself must be done efficiently to match modern operating procedures.

Vulcan precisely-controlled automatic soot blowing systems meet this specification.

They save time. One blower automatically follows another as programmed. Indexing is a matter of seconds.

They save labor. Merely pushing a button starts automatic operation. The operator or computer controls the whole system from one central location.

They save fuel. Cleaning is better because operation is positive and at proper intervals. Steam—which means fuel—and air are saved because of precise timing.

Combustion

EDITORIAL

Mahomet and the Mountain

With the disturbing condition the world finds itself in today it is somewhat reassuring to come up against one important segment of the economy still carrying on business as usual. The program of the recently concluded National Power Conference in San Francisco could be characterized as a typical engineering society meeting with the usual sprinkling of review papers, status reports and challenges to some of the more conventional practices. But against "the bomb heard round the world" the paper, reprinted in full in this issue, page 30, by W. E. Hopkins, takes on more import than would otherwise be the case.

Mr. Hopkins' subject—the cost of transporting energy—is a recurring one with the cost-conscious power industry. It has been looked at time and again and these looks have produced a number of ideas and suggested solutions ranging from generating power at the mine mouth to moving fuel through pipelines to arranging an assured return-trip cargo for coal barges. Many of the ideas have been and are being tested and employed. But all on the assumption that the conventional, time-honored method of moving fuel in bulk will still be standing by if all fails—the heretofore great railway system of the nation. In this day and age, though, the old standby "ain't what she used to be."

We have all of us been witnesses to the relatively recent yet apparently systematic abandonment of much of the railway industry's might—its freight yards, roadbeds and track—to lighten what that industry feels to be ruinous taxes. Some few years back when we editorialized on the fuel glut we quoted from a 1954 talk by Philip Sporn before the Supply Section of the Institute of Electrical Engineers in London, England. Its point, we think, still holds. We repeat:

"One danger which is facing the American power industry may come about as a result of the coal industry's subjection to very difficult competitive forces over the next decade, and then perhaps being asked at the end of that time, after a protracted condition of relative starvation, to pick up and do a giant's job in a national emergency." This danger, we now believe, is compounded.

Certainly the "difficult competitive forces" have been felt by the suppliers of the power industry's principal fuel. But the impact has not stopped there. Its carriers this decade have felt "the difficult competitive forces" too and in some measure capitulated. How far this capitulation has gone and to what measure it may affect the coal buyers' deliveries we do not know. We certainly believe, though, that the power industry should check this out before it finds itself in Mahomet's plight. It's been a very comforting feeling all these years to know that the mountain will and can come at your call.

Normally the largest single item of expense associated with power generation consists of charges for fuel. This paper reviews factors influencing future fuel availability and costs and provides comparative costs of other energy transmission methods. Application of these factors to existing situations indicates areas that could benefit from the use of alternative energy transmission concepts.

Transportation of Electrical Energy vs. Transportation of Fuel*

By W. E. HOPKINS[1]

Stone & Webster Engineering Corp.

THE ELECTRIC utility industry is faced with the problem of operating within the limits of regulated revenue rates and continually rising costs. In addition, the lack of direct competition fosters more subtle comparative competition which, unfortunately, does not immediately distinguish differences in such factors as location, distribution area and service requirements, relative size and growth rate, required plant utilization factor and basis of investment capitalization.

To meet these problems, the industry must continually re-evaluate cost control procedures applied to all phases of their operations. The extended life and relative rigidity of equipment associated with power generation dictates institution of cost control procedures based on recognition and long range prediction of variable cost influencing factors.

Fuels and Transportation Methods

Historically, competitive fuels available for thermal electric power generation have been bituminous coal, natural gas and residual fuel oil. Recent technological advances in nuclear plant design and governmental revision of applicable fuel charges indicate that electrical energy from this fuel source can be considered competitive in certain situations.

Fig. 1, indicates the relative share of fuels used since 1922 and authoritative estimates of future fuel use division. Heretofore, a majority of thermal generating plants have been located at or near distribution centers and the indicated fuel use division illustrates proximity of major distribution centers to particular fuel sources as well as the effect of relative delivered fuel prices.

The advantage enjoyed by the utility industry through possible thermal generation with different fuels is shown by the indicated fluctuations in use which can be traced directly to introduction of competitive transportation methods and fluctuations in delivered fuel prices.

Developed sources of bituminous coal are, in general, concentrated in the eastern and east central section of the United States. Large proved reserves exist in the western areas of the country but insufficient demand and lack of competitive transportation facilities have deferred their large scale development.

Fig. 2, traces previous distribution of production and indicates estimated future division. Normal transportation methods include rail cars, barge and smaller amounts by truck to consuming areas or to ship ports for distribution to more distant locations. Larger bulk shipments possible with barge delivery reduce unit costs considerably but approximately 75 per cent is shipped by rail due to limitations imposed by source or consumer location.

The most abundant developed sources of natural gas are located in the South Central, South Western and Pacific areas of the United States.

Fig. 3, traces previous distribution and indicates estimated future division of use. Transportation to consuming areas is accomplished through pipelines.

Residual fuel oil is a by-product of crude oil distillation and its availability as a power generation fuel is a function of demand for superior products and distillation efficiency. Major areas of production are the South Central and Pacific sections of the United States or foreign sources.

Fig. 4, illustrates residual oils' dependence on demand for other products. Indicated also on this figure is the

* Presented before the National Power Conference, San Francisco, Calif., Sept. 25–27, 1961 as AIEE Conference Paper CP-61.

[1] Consulting Engineer.

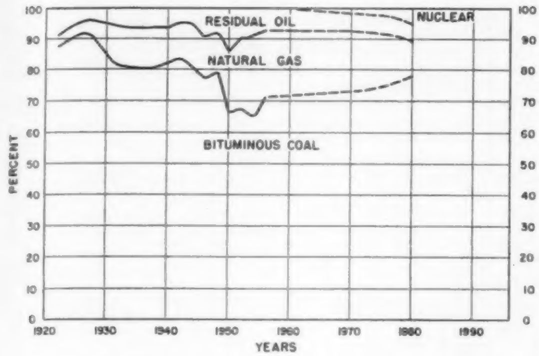


Fig. 1—Thermal electric power generation has employed the fossil fuels in varying amounts over the years. For example in 1960 coal supplied about 71 per cent of the needs, gas 22 per cent and residual oil about 8 per cent

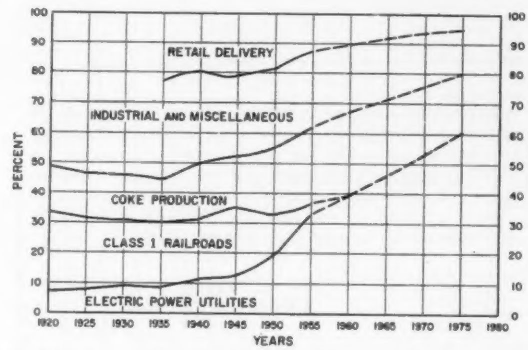


Fig. 2—The breakdown of bituminous coal consumption by user shows above. Again for 1960 the power companies accounted for 40 per cent of all the coal used, the coke producers 28 per cent, industrial and miscellaneous customers 22 per cent, and the retail market 10 per cent

relative distribution of residual fuel oil among consumer classes. Limited distribution of residual oil is made by pipeline but a major portion is delivered by tanker.

Delivered Fuel Costs

Fig. 5, indicates the relative value of these fuels at the source in dollars per Btu since 1922 and includes authoritative estimates of future prices.

Fig. 6, illustrates the average delivered prices paid by utilities in different areas of the country between 1954 and 1959.

Delivered thermal power generating fuel costs, although based on raw fuel prices at the source, are determined by a complicated interrelation of supply and demand, availability and method of transportation, transportation distance, competition between fuels, competition between users of each fuel and governmental regulation of fuel production and transportation.

Recognition of the historical and future trend of these influences provides significant contributions toward evaluation of alternative energy transmission concepts.

Average bituminous coal prices reflect production of many grades from all types of mines. Included are higher quality metallurgical and coking coals as well as production from older mines. Technological improvements in mining equipment and methods have nearly doubled the average output per man in the last decade. Mechanized underground and strip mining techniques require less than half the average man-hours per ton of coal produced. Although these factors will have a decreasing effect on average prices in the future, the outlook for minimum future mine price increases is generally considered to be favorable.

Regulated rail transportation rates normally form a considerable portion of total delivered coal costs. Existing competitive influences have forced management and the regulating agencies toward revision of arbitrary rate schedules. The railroads are giving consideration to larger bulk hauling trains to reduce costs. Although changes may be limited to special situations, the evidence suggests determined efforts to compete with other forms of transportation. Despite these efforts, nominal increases in rail transportation costs are to be expected over an extended period.

The indicated average natural gas prices reflect existing long term contracts negotiated at relatively low levels. Recently, negotiated contracts in some instances are based on values nearly double the existing average. "Favored Nation" contractual arrangements tend to adjust the average closer to current values but the full

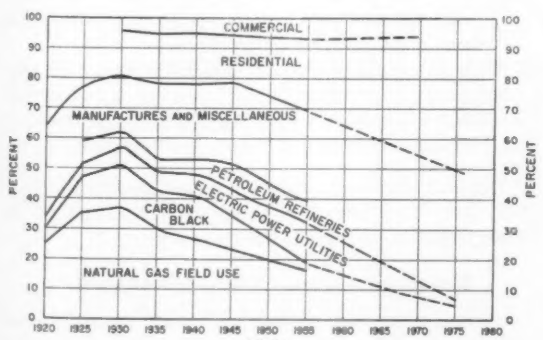


Fig. 3—The above illustration is similar to Fig. 2. It portrays the breakdown of natural gas consumption by major user groups

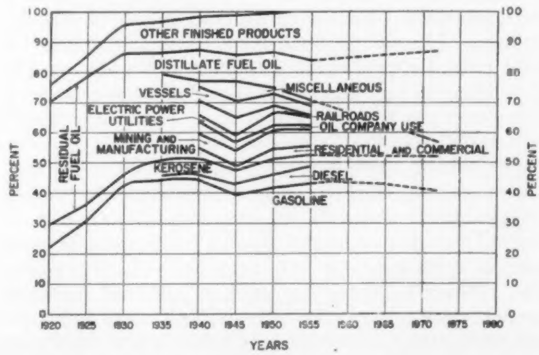


Fig. 4—In a similar manner to that of Figs. 2 and 3 this illustration presents the breakdown of oil production by the major products supplied.

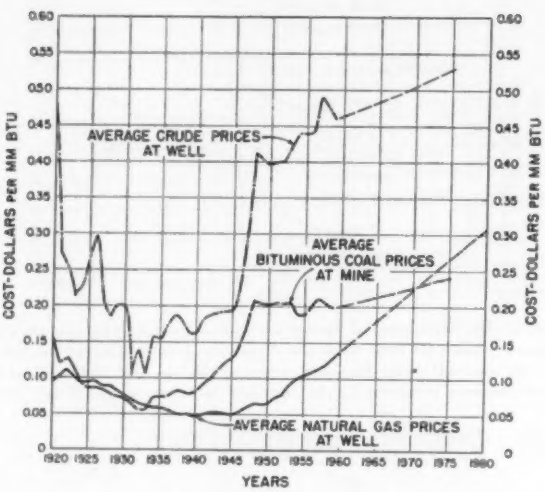


Fig. 5—The above set of curves depicts the average prices in dollars per MM Btu for each of the fossil fuels at their point of origin

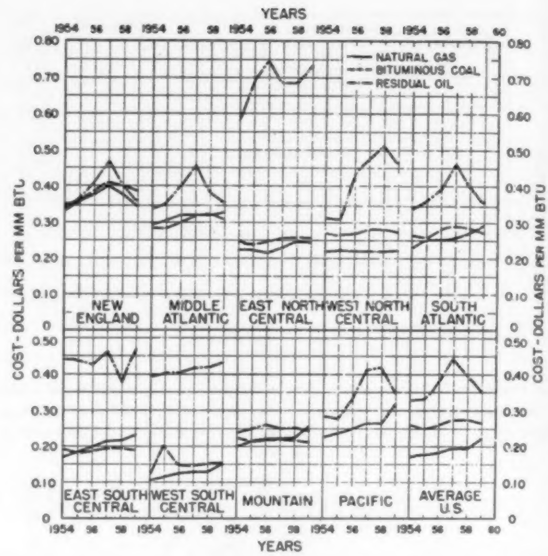


Fig. 6—Pictured above by U.S.A. geographical regions are the statistical average costs for the three fossil fuels as delivered to the user

effect of today's values will not appear until older contracts expire. The nature of some recent contracts indicates that gas prices could triple within the next 20 years. There is no question that future gas prices will be considerably higher than at present.

Seasonal fluctuations in demand by other consumers have offered thermal power generating plants an opportunity to contract for gas on an interruptible basis at extremely favorable transportation rates. In fact, there is some evidence to indicate that these rates in some cases are more a function of competing fuel prices in the area than actual transportation costs. An increasing number of distribution center "peak shaving" storage facilities is being constructed, however, to minimize the effect of consumer demand fluctuations. Acceleration of this trend in providing continual high load factor pipeline operation, so necessary in the determination of economical transportation rates, can be expected and gas available for power generation on an interruptible contractual basis will diminish rapidly in the future.

Residual fuel oil availability is wholly dependent on influences outside of the control of thermal power generation consumers. Increasing demand and value of other products of crude oil distillation have accelerated the trend toward higher yields. In the last decade, residual oil production has decreased from 20 to approximately 12 per cent per barrel of crude oil. Since residual oil is the only distillation by-product selling below the cost of the crude oil, there is a strong incentive for even higher efficiencies. In addition, rigid domestic production and foreign import controls are imposed, determined by demand for other oil products and a compromise between political considerations and domestic industry protection. Power generation consumers also are forced to compete with other users such as ships, small industries and commercial establishments where labor costs associated with the use of other fuels prohibit their economic use.

Although presently priced for disposal in competition with other fuels, the long term effect of a combination of the above influences will be a continual reduction of the available supply and an increase in price for power generation consumers due to competition from other users.

Utility Industry Fuel Cost Control

Traditionally, improved plant efficiency has been used to control total fuel costs. Average coal consumption per kwhr has decreased from over 3 lb in 1920 to 1.1 lb in 1959 with individual modern stations requiring considerably less fuel. This internal control method balances fuel costs against fixed charges, however, resulting in a net gain considerably less dramatic.

Other methods of controlling fuel costs investigated or adopted by individual utilities include the following:

1. Dual fuel use design to take advantage of seasonal or competitive prices.
2. Selective plant location based on fuel transportation rate differentials.
3. Joint transportation facility ownership to divide combined fuel and other commodity movement costs.
4. Separate transportation contracts for fuel purchased at the source.
5. Electrical transmission from favorable plant sites.
6. Nuclear fuel fired generating stations.

In general, however, thermal power generating consumers have been forced to accept a passive role in the determination of delivered fuel costs.

Comparative Energy Transmission Costs

Since fuel costs vary considerably with plant location relative to the fuel source, method of fuel transportation and fuel type, this paper has been arranged to segregate costs associated with construction, operation and main-

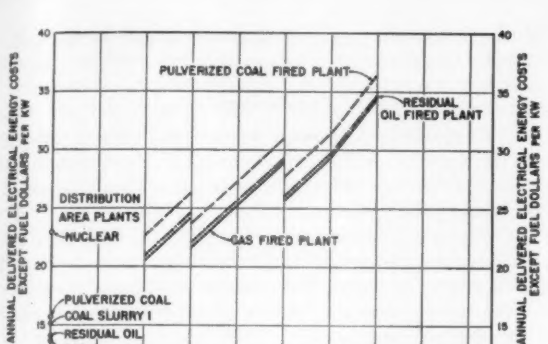


Fig. 7—Costs shown, left, are those chargeable against energy for operating including auxiliary power, maintaining (both labor and materials), transmission lines loss and annual fixed charges on investment. Fuel is not included. In addition the costs for specific pulverized coal, residual oil and natural gas fired plants are portrayed at specified distances from the centers of distribution allowing for all differences between these designs

tenance from fuel requirements. The following five types of plants were considered:

I—Natural gas fired plant
II—Pulverized coal fired plant
III—Slurry coal fired plant
IV—Residual oil fired plant
V—Nuclear fired plant

Fig. 7, indicates the annual costs per kw delivered associated with each type of plant located in the distribution area. In addition, Fig. 7 includes annual costs of natural gas, pulverized coal and residual oil fired stations located at varying distances from the distribution area combined with electrical transmission of energy to the distribution area. All costs are based on delivering identical quantities of energy to the distributions area by including allowances for differences in auxiliary power requirements, operating and maintenance labor costs, maintenance material costs and transmission line losses. For distances from 200 to 300 miles, costs are based on transmission at 230 kv. For distances between 300 and 500 miles, the costs are based on 345 kv transmission. Above 500 miles, the costs are based on transmission at 575 kv. Annual fixed charges on investment have been computed at 15 per cent. Lower fixed charge rates would favor electrical transmission systems and nuclear plants where investment costs are considerably higher. All costs indicated on this plate are based on maximum capacity factor operation and must be adjusted to reflect expected actual operating capacity factors to obtain costs per kwhr delivered.

Fig. 8, indicates the annual fuel requirements per kwhr delivered for each type distribution area plant considered. To indicate the effect of variations in operation, fuel requirements are shown for 60 per cent and 90 per cent capacity factor operation for all plants, except a coal slurry fired station. Previous proposals for furnishing pipeline delivered coal slurry have been predicated on the 90 per cent capacity factor operation indicated on the plate for this type plant. Fig. 8 also includes fuel requirements of natural gas, pulverized coal and residual oil fired stations located at varying distances from the distribution area combined with electrical transmission of energy to the transmission area. As with the costs given on Fig. 7, the fuel requirements are predicated on delivering identical quantities of energy to the distribution area by including allowances for differences in boiler efficiency, auxiliary power requirements and transmission line losses. Allowances for transmission line losses are based on transmission at 230 kv, 345 kv and 575 kv.

The information presented on Figs. 7 and 8 is arranged for comparison with existing practices in any area. Since numerous combinations of operating capacity factor and delivered fuel costs are possible, typical combinations have been selected to indicate situations where the newer concepts in energy transmission may be attractive.

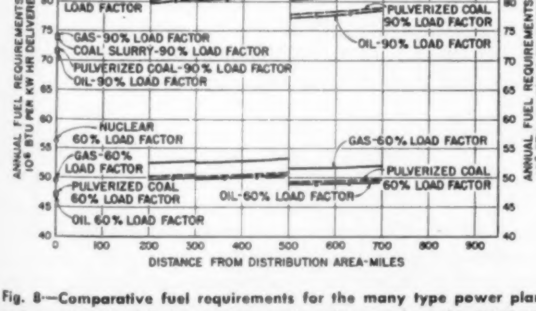


Fig. 8—Comparative fuel requirements for the many type power plants under various load factors and at varying distances from the distribution area are presented above

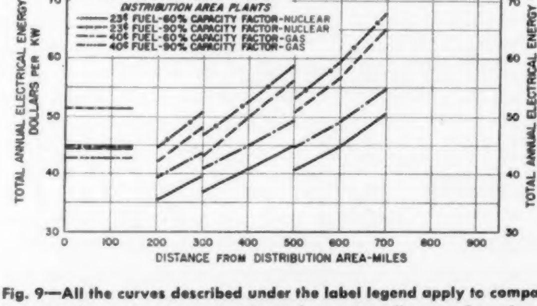


Fig. 9—All the curves described under the label legend apply to comparative costs for a natural gas plant located at various distances from the distribution area under different load factors and unit fuel costs. The other curves are explained under distribution area plants

Fig. 9, indicates total annual costs per kwhr delivered associated with a natural gas fired plant located at various distances from the distribution area with delivered fuel costs of $0.15 and $0.20 per MM Btu and operating capacity factors of 60 and 90 per cent. For comparative purposes, total costs associated with distribution area, gas and nuclear fired generating facilities operating at the same capacity factors with delivered fuel costs of $0.40 and $0.23, respectively, have been indicated. Analysis indicates that with this combination of factors, distribution area nuclear fired plants could be economical with high capacity factor operation. Economies could also be achieved with EHV electrical transmission where high capacity factor operation is possible. For minimum operating capacity factors, EHV electrical transmission can only be justified where relatively inexpensive fuel can be obtained.

Fig. 10, indicates total annual costs per kwhr delivered associated with pulverized coal fired stations located at various distances from the distribution area with similar delivered fuel costs and operating capacity factors. Total costs associated with distribution area pulverized coal, nuclear and pipeline delivered coal slurry fired generating stations are indicated for comparative purposes. Here again, with the combination of factors used, nuclear fired plants and long distance EHV electrical transmission of energy could be attractive under high capacity factor operating conditions. Analysis also indicates that pipeline delivered coal slurry, where economical transportation rates are predicated on 90 per cent capacity factor operation, can only compete with EHV electrical transmission of energy under special circumstances.

Fig. 11, indicates similar total annual costs per kwhr delivered for various combinations of fuel costs and operating capacity factors for an oil fired generating station. In this instance, nuclear fired distribution area station could only be attractive at capacity factors of 90 per cent and above. Similarly, high capacity factor operation could make EHV electrical transmission from a relatively inexpensive fuel cost area economically attractive.

Various additional combinations of generating plant locations, distribution area delivered fuel costs, fuel costs at the source and operating capacity factors can be analyzed through use of the information outlined in Figs. 7 and 8. Application of specific variables for a given area could readily indicate situations where alternative energy transmission concepts are attractive enough for more detailed investigation.

Conclusions

1. Competition between fuels, fuel consumers and fuel transportation methods is the most important single factor influencing thermal power generating delivered fuel costs.

2. Natural abundance, technological production improvements and transportation facility competition will limit future delivered bituminous coal price increases thereby continuing its dominance as the main thermal power generating fuel.

3. Accelerated "superior use" demand will increase the price of natural gas at the source which combined with extensive distribution area "peak shaving" storage facilities will severely reduce its availability as a competitive power generating fuel.

4. Increasing crude distillation efficiencies and competition from consumers having no other economic alternative will restrict supplies of residual fuel oil available for power generation. In addition, the unpredictability of national and world political events will induce severe price fluctuations.

5. For those areas and distribution systems where base loaded electric generating capacity is required, nuclear fuel fired plants can be competitive.

6. Pipeline transportation of coal slurry can compete with EHV electrical transmission of energy only under special circumstances.

7. EHV electrical transmission of electrical energy can be economical in a wide variety of situations where relatively high capacity factor operation is permissible or where relatively high fuel transportation costs occur.

While long term technological improvements in nuclear plant design will make this method of electrical generation attractive, the development of EHV electrical transmission systems offers the utility industry immediate benefits as a stabilizing influence to replace the rapidly diminishing competition between fuels and to provide competition for existing methods of fuel transportation. Review of current and probable future trends of factors influencing thermal power generation fuel costs indicates that new competition should be developed in many locations.

The demand for larger quantities of energy by separate

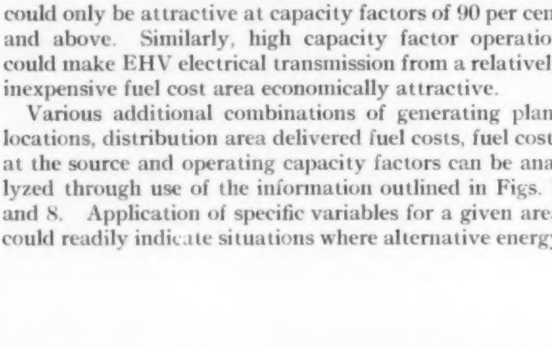


Fig. 10—The same family of curves for Fig. 9 are repeated for a pulverized coal plant

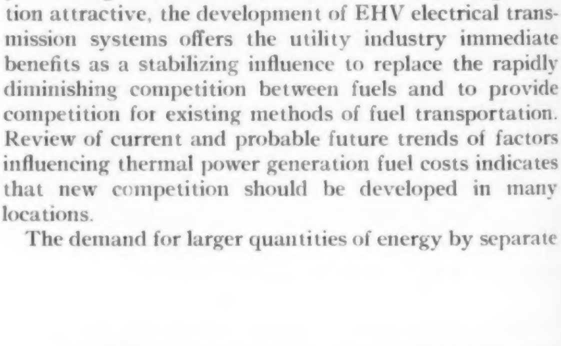


Fig. 11—Here again, and this time for oil, the same family of curves for Fig. 9 appear

distribution systems when considered individually could limit the number of economically competitive EHV transmission installations. However, the broad potential advantages of this transportation medium is inducive to industry cooperation in its use as well as its technological development.

Control of a competing transportation facility by the largest single fuel consuming industry could lead to aggressive participation in the determination of fuel costs. The industry could be free from complete dependence on intervening handling agents, subject to opposing influences and controls, for its fuel supply. Distribution area power generating stations will always be necessary but cooperative exploitation of this transportation method could be used to limit delivered costs of fuels priced in accordance with competition, or to force investigation or revision of unrealistic regulated transportation rate schedules.

The possibilities of regulatory control coincident with interstate energy transmission could act as a deterring influence on prospective participants in any cooperative venture. However, the potential advantages available through optimum use of EHV transmission should promote investigation of alternatives, such as creation of independent wholesalers or cooperatively financed subsidiaries.

Procedure for Laying Up Boilers Reported by NDHA

At the recent 52nd Annual Meeting of the National District Heating Assn the Steam Station Committee gave a review of present procedures for laying up boilers for standby service. These we will publish from time to time. Below you will find the reported procedures for short lay-up.

Chester M. Hutt, Boston Edison Co. summarized the procedures for laying up boilers for standby service, in use at the present time, by companies having representatives on the Steam Station Committee of the NDHA.

An examination was made of Boston Edison Co. files of past NDHA Proceedings to determine what has been reported in regard to this subject in the past. Since 1931 this topic has been on the program five times—in 1934, 1935, 1939, 1943 and 1947. Some of these papers included very complete descriptions of methods currently in use at the time the papers were presented.

Due to the fact that it has been 15 years since this subject was discussed a questionnaire was prepared as a means of accumulating information. Replies were received from ten different companies, one of which submitted lay-ups of both stoker and pulverized coal fired boilers and another that described lay-ups of stoker and oil fired boilers. Detailed tabulations of the answers to this questionnaire were included in an Appendix to this paper.

Several questions were asked, to which all companies gave negative replies. (1) Test coupons are not installed inside boilers during a wet lay-up to determine whether a corrosive action is in progress. (2) Boilers are not drained periodically during a wet lay-up. (3) Boilers are pressurized with an inert gas on a wet lay-up except as follows:

Company B purges the boiler of air and then keeps it under a pressure of 5 to 20 psi from the continuous blow down header or boiler feed suction header.

Company C uses nitrogen to provide a cap on the steam drums and superheater on their 1000 psi boiler. However, this boiler operates at a higher pressure than most District Heating Company boilers.

Company E is not using nitrogen at present but intends to do so in the near future.

The subject of boiler lay-up can have many ramifications. It can include the boiler, all the inlet air and outlet gas paths, feedwater equipment, instruments, steam piping within the station and electrical equipment associated with the boiler.

In the questionnaire an attempt was made to get an expression of opinion, on lay-up procedures for mechanical equipment, from all committee members. In some cases it was difficult to decide whether the precautions taken should be properly considered as routine maintenance work or boiler lay-up procedure, but all answers were included because valuable information may be obtained from them.

The questionnaire was confined to low-pressure boilers of the type that are commonly used on district heating systems and is separated into three types as follows:

1. Short Lay-Up Period—for periods when the boiler is to be shutdown for a few days at a time between periods of cold weather. Boilers in this category are usually considered to be in peaking service.

2. Medium Lay-Up Period—when the boiler is off the line for several months; for example, during a seasonal lay-up in the summer.

3. Extended Lay-Up Period—if the boiler is used only in case of a system emergency which may occur only at rate intervals.

An expression of opinion was also requested as to the length of time that would be required to start up a 100,000 lb/hr boiler with each type of lay-up.

Short Lay-Up Period

Boiler tubes are cleaned with soot blowers or an air lance.

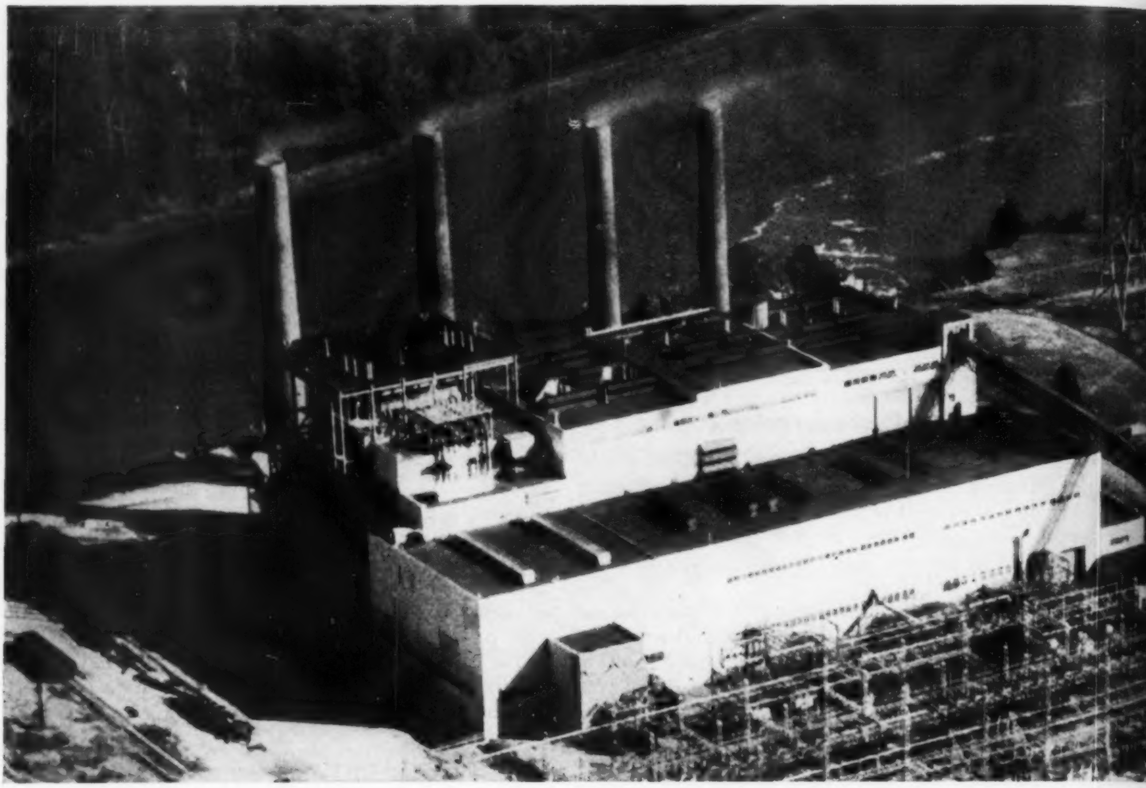
A wet lay-up is always used for the water side of the boiler to minimize corrosion. The water used is made alkaline with caustic soda and/or trisodium phosphate. In most cases these alkaline materials are added to maintain a pH of 11 or better. Some companies also add sodium sulfite to eliminate dissolved oxygen.

There appears to be a relatively wide range in the concentrations of chemicals used to provide protection.

Very few measures are taken to protect air or gas ducts or fans. One company turns over fans periodically and two others close gas duct dampers.

Deaerators are pressurized with steam by 4 companies during this type of boiler outage.

The length of time required to put a 100,000 lb/hr boiler in service using this type of lay-up varied from $^1/_2$ to 4 hours with the mean being $1^1/_2$ hr.



VEPCO's Chesterfield Station to get system's

Utility Power Stations which have C-E Controlled Circulation Steam Generators installed or on order:

Company	Station	Company	Station
Alabama Power Company	Barry	Houston Lighting & Power Company	Sam Bertron
Boston Edison Company	Mystic	Illinois Power Company	Hennepin
Carolina Power & Light Company	Cape Fear	Illinois Power Company	Vermilion
Carolina Power & Light Company	H. B. Robinson	Illinois Power Company	Wood River
Central Hudson Gas & Electric Corp.	Danskammer	Kansas Power & Light Company	Tecumseh
Central Illinois Public Service Company	Meredosia	Kansas Power & Light Company	Lawrence
Cincinnati Gas & Electric Company	Miami Fort	Kansas City Power & Light Company	Montrose
Cincinnati Gas & Electric Company	Walter C. Beckjord	Metropolitan Edison Company	Portland
Cleveland Electric Illuminating Co.	Ashtabula	Montaup Electric Company	Somerset
Cleveland Electric Illuminating Co.	Eastlake	New England Power Company	Brayton Point
Cleveland Electric Illuminating Co.	Lake Shore	Niagara Mohawk Power Corporation	Dunkirk
Commonwealth Edison Company	Will County	Niagara Mohawk Power Corporation	Charles R. Huntley
Commonwealth Edison Company	Crawford	Northern Indiana Public Service Company	Dean H. Mitchell
Commonwealth Edison Company	Fisk	Pennsylvania Electric Company	Seward
Commonwealth Edison Company	State Line	Pennsylvania Electric Company	Shawville
Commonwealth Edison Company	Waukegan	Pennsylvania Power & Light Company	Brunner Island
Commonwealth Edison Company	Joliet	Philadelphia Electric Company	Schuylkill
Connecticut Light & Power Company	Norwalk Harbor	Philadelphia Electric Company	Cromby
Consolidated Edison Co. of N. Y., Inc.	Astoria	Potomac Electric Power Company	Dickerson
Consolidated Edison Co. of N. Y., Inc.	Ravenswood	Potomac Electric Power Company	Potomac River
Consolidated Edison Co. of N. Y., Inc.	East River	Public Service Electric & Gas Company	Kearny
Consumers Power Company	John C. Weadock	Rochester Gas & Electric Corp.	Russell
Consumers Power Company	B. C. Cobb	Rochester Gas & Electric Corp.	Beebee
Consumers Power Company	Dan E. Karn	South Carolina Electric & Gas Company	Canadys
Consumers Power Company	James H. Campbell	South Carolina Electric & Gas Company	Silas C. McMeekin
Detroit Edison Company	St. Clair	Southern California Edison Company	Etiwanda
Detroit Edison Company	River Rouge	Southern California Edison Company	Alamitos
Duke Power Company	Allen	Tennessee Valley Authority	Widows Creek
Duke Power Company	Dan River	Tennessee Valley Authority	Gallatin
Duke Power Company	Riverbend	Tennessee Valley Authority	Kingston
Duke Power Company	Buck	Tennessee Valley Authority	John Sevier
Duke Power Company	Lee	Virginia Electric & Power Company	Yorktown
Duke Power Company	Marshall	Virginia Electric & Power Company	Possum Point
Florida Power & Light Company	Port Everglades	Virginia Electric & Power Company	Portsmouth
Georgia Power Company	McDonough	Virginia Electric & Power Company	Chesterfield
Gulf States Utilities Company	Sabine	West Penn Power Company	Mitchell
Houston Lighting & Power Company	T. H. Wharton	Wisconsin Electric Power Company	Oak Creek

A New Arrangement For a Steam Turbine By-Pass

By J. B. Prather* and J. H. Potter†

Gibbs & Hill, Inc. Stevens Institute of Technology

The need for close matching of steam and metal temperatures to reduce startup times and certain specialized problems of once-through boilers has prompted some to develop by-pass arrangements. Here is one such development as applied to a 150-Mw, 2400-psig, 1000-F, 1000-F unit.

IN RECENT years a number of central stations have been designed with provisions for by-passing the main turbine with 30 per cent or more of the full load throttle steam flow. Apparently such by-passes are becoming more important where larger units and more flexible operation are concerned.

By-pass systems serve several functions depending upon the type of power units in which they are installed. In general, however, they can be classified under one of the following categories:

(*a*) By-pass to match steam and metal temperatures in a conventional fossil fuel cycle. This serves to avoid excessive thermal shock in the turbine at start-up.

(*b*) By-pass for start-up and trip-out when a once-through type boiler is used. By this means water and steam are recycled until proper steam flow and steam temperature are established prior to starting and loading the turbine generator.

(*c*) By-pass for start-up and trip-out in a nuclear fuel cycle. In some nuclear power plants a by-pass may be required for starting a secondary steam cycle. This also provides a means for conserving valuable condensate when the electrical load is dumped and the residual reactor heat must be dissipated.

Although different purposes are served by each of the by-pass arrangements cited above, certain design criteria are common to all. In each case provision is made for throttling and cooling a considerable quantity of superheated steam. The throttling is accomplished by expansion through reducing valves, piping, and a series of orifices of increasing area; water sprays are used to cool the steam. The steam is then dumped to the main condenser, which operates at a relatively high vacuum.

For the once-through boiler cycle, there is the added requirement for handling water and a mixture of water and steam in the initial stage of the by-pass system. This is effected by high pressure flash tanks or separators incorporated in the first stage of the by-pass installation. A system of this type was used at the Eddystone Station of the Philadelphia Electric Company.[1]

Operational difficulties have been encountered in other stations in which large quantities of steam were dumped to the condenser. This has resulted in the physical failure of hangers and supports due to severe vibration. The noise levels in some installations have been excessively high, causing considerable discomfort to the operators. With these facts in mind, it was considered desirable to devise a unique and original arrangement for expanding and dumping the large volumes of by-pass steam into the main condenser.

A recent application of by-passing and steam-dumping was made at Naples, Italy.[2] Here, a once-through boiler is used in conjunction with a 150 Mw turbine. The Naples installation, known as the Levante Power Plant, will consist ultimately of three 150 Mw steam electric units. The first of these, placed in service in February 1961, is designed to operate with initial steam conditions of 2400 psig, 1000 F, with reheat to 1000 F. Although the steam pressure is not supercritical, a once-through boiler design was selected by the owners, Societa Meridionale di Elettricita, and an appropriate condensate

* Engineer, Gibbs & Hill, Inc.
† Stevens Institute of Technology, Consultant, Gibbs & Hill, Inc.

[1] "The Eddystone Superpressure Unit," By C. B. Campbell, C. C. Franck, Sr., and J. C. Spahr, A.S.M.E. Paper 56-A-156.
[2] Designed jointly by Gibbs & Hill, Inc., of New York, N. Y. & Ansaldo, S.A., of Genoa, Italy.

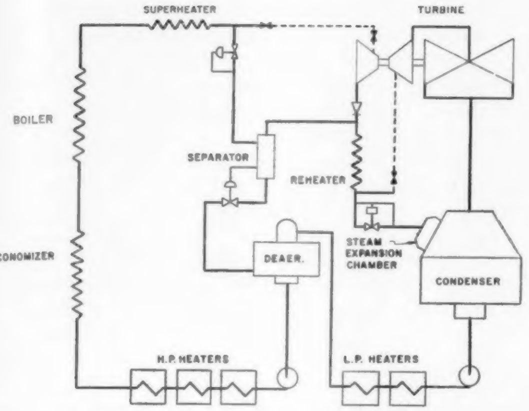


Fig. 1—Once-through boiler selection for a sub-critical installation at Levante Power Plant, Naples, Italy, employs above by-pass system capable of handling 30 per cent of full load. Initial steam flow in the form of either steam or water

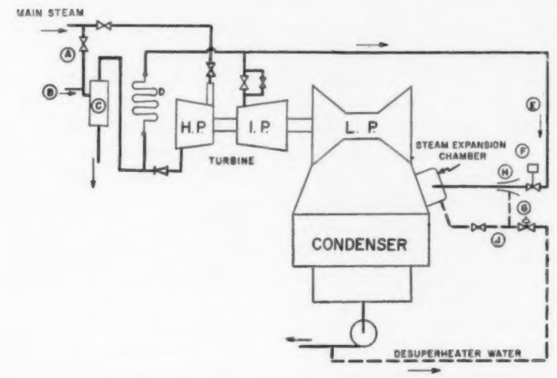


Fig. 2—Severe vibration, overly high noise levels occurred from the movement of large quantities of steam direct to the condenser. Above arrangement described in full in the text has been proven capable of answering these objections

make-up and polishing system was included in the design.

The once-through boiler selection led to the need for designing a by-pass system capable of handling 30 per cent of the full load initial steam flow in the form of either water or steam. The arrangement is shown on the cycle diagram, Fig. 1.

This arrangement, which has now been proven fully satisfactory, is described herein and is shown on the flow diagram, Fig. 2. Steam from the superheater is expanded through valve (*A*) and is mixed with water sprays (*B*) after which it enters separator (*C*). It then flows through the reheater (*D*), serving to protect this unit against excessive temperatures. The steam then flows to the spillover valve (*F*), which is adjusted so as to limit the downstream pressure, that entering the steam dump chambers, to 100 psi. Reduction in the enthalpy of the steam is accomplished by the addition of spray water in the mixing chamber (*H*) located between the spillover valve and the condenser.

While considerable experience is now available concerning the valving and piping problems which exist between the superheater outlet and the intermediate pressure section of the by-pass system, very little has been published with regard to the low pressure throttling and steam dumping problems. Among the latter are the difficulties, detailed in the following section, encountered in the discharge of large quantities of relatively high temperature steam to the condenser. Special and unique throttling chambers meet this problem at Naples.

The throttling and spray-cooling of the steam at the Levante Station is done in "dump" or steam expansion chambers. Actually two dump chambers were installed in order to furnish sufficient area for the arrangement. These were attached externally to the sloping sides of the condenser neck.

Design of the Dump Chamber *(See Fig. 3, facing page)*

The design criteria for the dump chamber included:

(1) *Limitations imposed by the condenser.* These included the fact that the chambers had to be located on the sloping sides of the condenser neck. The presence of feedwater heaters in the condenser neck further obstructed the steam flow. As a result, there were space limitations both inside and outside the condenser that restricted the size and location of the chambers. To avoid excessive thermal expansion, with resulting stresses in the large exhaust elements, the temperature of the incoming steam was limited to 160 F.

(2) *Use and location of water sprays.* In order to realize the 160 F entering temperature it was desirable to add spray water in an expansion where the pressure would be that of saturated steam at 160 F. Thus the sprays were located in one of the last passes of the chamber. This had the further advantage that the sprays were more accessible for maintenance.

(3) *Selection of materials.* Wherever possible mild steel was used in the design. Stainless steel was specified for the water piping and in a thin liner.

(4) *Control of noise level.* Both as an operating nuisance and as a source of vibration potentially capable of causing fatigue failure, high noise level is undesirable. Noise control was effected by maintaining sub-sonic velocity in all the lines and each of the sections of the chamber over the entire flow range.

(5) *Simplicity of design.* The design was kept simple by assembling and welding common rolled and flat sections of steel plate, and by arranging the elements for ease of maintenance.

(6) *Reasonable cost.* The combination of low cost materials and simple design made it possible to produce the dump chambers at reasonable cost.

At Naples, each of the chambers measures roughly 85-in. x 58-in. x 60-in., and is made from carbon steel plates formed and welded as shown in Fig. 3. A 0.10-in. stainless steel liner is used as a cover as shown at (E). This was done to minimize the erosive effects of high-velocity wet steam and entrained water.

The design principle of the chamber is that of a series of orifices of increasing area, arranged so that the velocities are at or below the sonic velocity, and with provision for dissipating the kinetic energy between expansions. In operation the dump chamber is analogous to a steam turbine with open throttle and with the rotor locked in place, as the successive areas increase in the direction of falling pressure.

Referring to Fig. 3, the steam enters the chamber through pipe (A) at the center of a nested group of half-cylinders, and expands through perforations provided on one side of the pipe (A). The restrictions to steam flow are sized and arranged to provide not more than a critical expansion at each throttling during maximum flow. To prevent spillover between sections, the half-cylinders are overlapped by 10 degrees of arc where they attach to the supports (B). To avoid whirls and to maintain even steam distribution, dams (C) are provided. The supporting members are arranged to minimize resistance to steam flow. The rectangular openings resulting from the arrangement of the nested half-cylinders form nozzles in which the steam expansions approach reversible adiabatic performance.

Following each expansion, the steam undergoes a path reversal of 180 degrees, during which no work is done. The kinetic energy is therefore dissipated, and the steam is reheated at constant pressure toward the initial enthalpy. The steps in the throttling operation are shown in the h-s plane in Fig. 4.

In the first five expansions it has been assumed that reversible adiabatic expansions have been achieved between the initial enthalpy and the pressure corresponding to the critical pressure. In Fig. 3, cooling water is brought into the chamber at (D) through a stainless steel line, and is distributed in branches to spray nozzles. The introduction of the spray water in the sixth expansion causes a sharp drop in the enthalpy of the steam. This is shown in Fig. 4, where the enthalpy is reduced to h_6.

The seventh expansion takes place between the outer half-cylinder and the casing wall. A final expansion ensues between the bottom flange and the outermost cylinder. In this instance the steam flow is deflected but the direction is not reversed prior to the expansion, hence there is a considerable approach velocity. The initial enthalpy in the last expansion is therefore less than h_6, as shown in Fig. 4. Also, the terminal expansion slightly exceeds the critical pressure ratio at 30 per cent of full throttle flow. As a result, it is assumed that the enthalpy leaving is at h_D instead of h_C. This does not seriously affect the operation, as was borne out by the prototype.

Conclusions

The chambers, placed in service at the Naples installation in January 1961, have been proved completely satisfactory over all operating load ranges.

They have operated quietly, indicating that the internal expansions do not seriously exceed the critical pressure drop in any stage.

The arrangement of the chambers and the by-pass steam piping is neat, compact, and pleasing.

The temperature of the chamber external shell, with design steam flow, has not exceeded 130 F, which is well within allowable limits.

The steam expansion chamber arrangement has been completely satisfactory, and it is anticipated that service will continue trouble-free in the future.

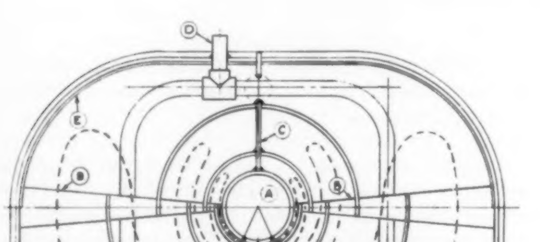


Fig. 3—Heart of the solution at Levante, Fig. 1, whose arrangement appears in Fig. 2, is the use of two chambers, above, whose workings involve a series of orifices arranged to hold velocities at or below the sonic level. Its workings are described in detail

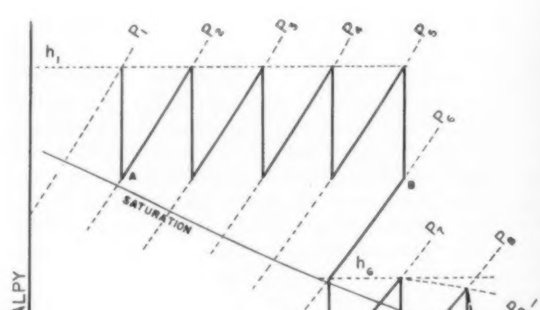
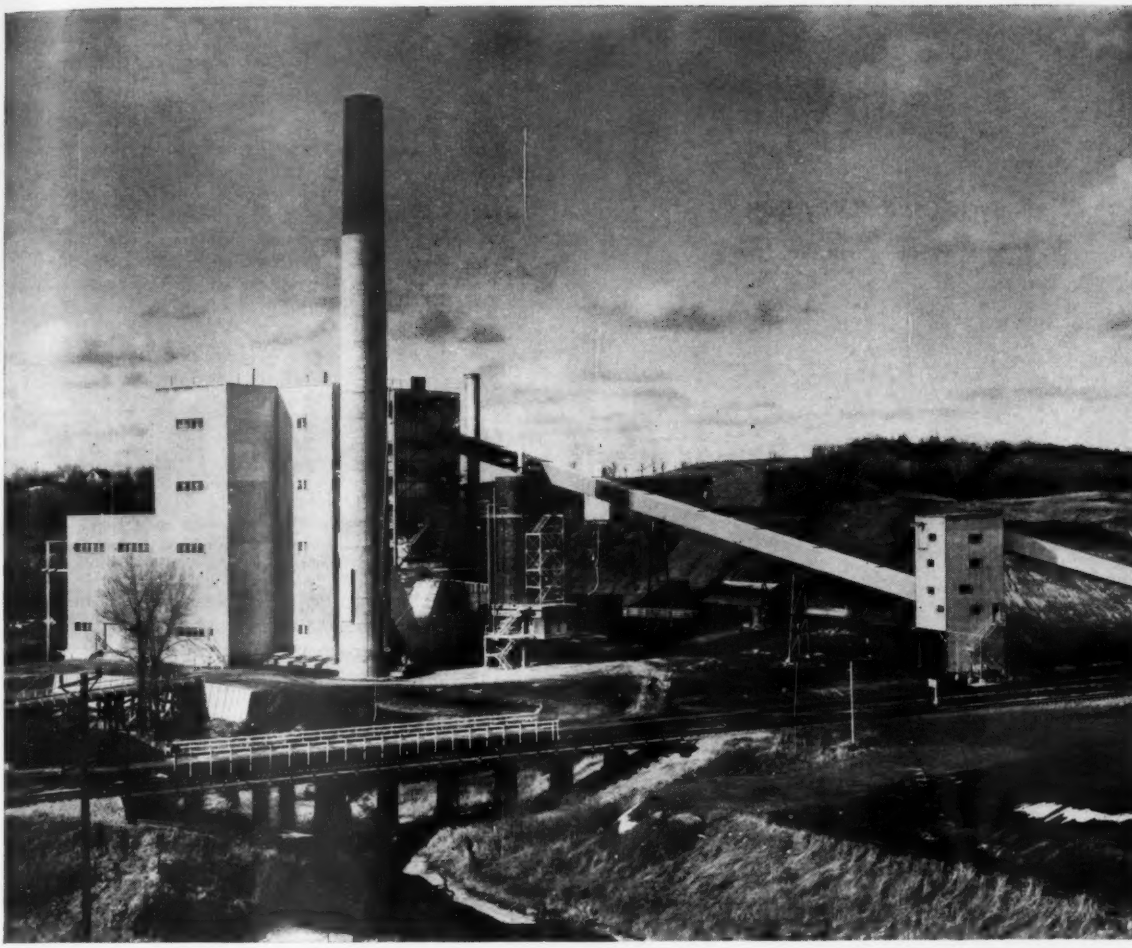


Fig. 4—Along with the physical picture of the chamber, Fig. 3, is the h-s diagram, above, showing the steps in the throttling operations



Rated at 53,500 kw, Hoot Lake is Otter Tail's newest station. The Otter Tail Power Company serves a 70,000 square mile area in Minnesota, North and South Dakota. Burns and Roe were consulting engineers.

MINNESOTA UNIT FIRES "WET" COAL

. . . Hoot Lake Station burns 1,000 tons of N.D. lignite daily

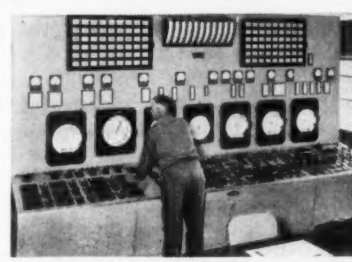
The Otter Tail Power Company's Hoot Lake Station at Fergus Falls, Minnesota, is the largest generating plant in the country burning North Dakota pulverized lignite. The steam generator is the first reheat unit to use lignite as the primary fuel.

Although lignite has a lower initial cost, its high moisture content (30-35%) and low heating value present unusual control problems.

After a year's operation, management is very satisfied with Hagan performance, particularly during several unscheduled outages, when the controls remained on automatic with excellent results. Hagan systems on the unit include combustion, 3-element drum-level, feed-pump, deaerating heater, forced, and induced draft fan control systems.

"Reasons for the selection of Hagan controls," one company official noted, "include satisfactory performance at our other stations, plus the high level of service and instruction provided by Hagan's Regional Service Engineer. We are pleased to have this same proficiency at our Hoot Lake Station."

Look to Hagan for sensible, workmanlike solutions to either special control problems or standard installations. A letter or phone call will put a Hagan engineer to work on your particular problem.



Control Panel at Hoot Lake. Hagan Ring Balance meters and the compact operating console make it easy for a single operator to maintain close control of the operation.

HAGAN
CHEMICALS & CONTROLS, INC.
HAGAN CENTER, PITTSBURGH 30, PA.

HAGAN DIVISIONS: CALGON CO. • HALL LABORATORIES • BRUNER CORP.

By IGOR J. KARASSIK*

Worthington Corp.

The boiler feed pump and its associated equipment represent a major operating and maintenance consideration in today's power plant. Here we run in question and answer form a series of clinic sessions on various boiler feed pump problems. The replies are the work of one of the topmost pump authorities and give specific information which we hope will prove valuable to our readers.

Steam Power Plant Clinic—Part XXV

QUESTION

At the present time we are supplying feedwater for reheat attemperation by withdrawing the required amount from the boiler feed pump discharge header and reducing its pressure through a valve. The maintenance of this throttling valve has been extremely expensive. Can the feedwater be withdrawn by tapping an intermediate stage of the boiler feed pump? Would not this arrangement provide the easiest source of attemperation feedwater?

ANSWER

Such an arrangement has actually been used in a number of installations, although I am not entirely convinced that it is the best or simplest solution, as you will see presently. I have once suggested in an article written in 1956 an alternate solution which I shall describe further in this Clinic. But first, I shall explain for the benefit of the readers of this Clinic the reasons for providing this attemperation feedwater.

In describing the history of the high pressure boiler feed pump, I have once quoted a British scientist who said "Progress is made by solving problems resulting from the making of progress." The statement is equally true, whether we are dealing with a major piece of equipment in the steam power plant or with some incidental side-effects introduced by improvements in the steam cycle. For instance, one of the problems introduced by the reheat cycle is that of the temperature control of the reheat steam. Very close regulation of the reheat temperature is necessary not only to retain the improvement in economy obtained by the use of reheat, but also to protect the reheater against failures from overheating and the main turbine against clearance difficulties caused by excessive thermal expansion.

Unless properly regulated by some external means, the reheat steam temperature varies with the load carried by the unit. This variation is caused by the fact that in a convection reheater, the effect of increased furnace temperatures and increased gas flows is to increase heat absorption by convection more rapidly than the steam flow through the reheater. As a consequence, the reheat temperature would normally increase with the load.

Several means to regulate this temperature have been used, among which one of the most common has been the use of spray-water attemperation. Feedwater is introduced in controlled quantities into the reheat steam line through a spray nozzle at the throat of a venturi section within the line. The vaporization is quite rapid and the feedwater introduced at the nozzle mixes with the reheat steam, cooling it to the required temperature by absorbing heat to vaporize the quantity introduced.

The spray-water must be of the highest possible purity, as any solids entrained in this water would enter the turbine and might cause undesirable deposits on the turbine blading. An excellent source of such water would be the drains from high pressure heaters. This would, however, require the use of a very special type of pump and disposal of drains at loads when no spray water is required might complicate the controls to some extent. As a result, the preferred source of spray water is the feedwater handled by the boiler feed pumps, provided the total solids are kept below 2 to 3 ppm concentration.

In most installations, automatic control of the injected flow is obtained by means of a two- or a three-element control. In the first, either the steam flow or the air flow to the furnace sets up the initial adjustment of a throttling valve in the spray line. The final or trimming adjustment is made from the final reheat steam temperature. When a three-element control is used, the initial adjustment is made by a relay responsive to the ratio between the steam flow and the flow of spray-water, while the final adjustment is again made from the reheat steam temperature.

The amount of water required for attemperation varies with each installation and, unfortunately, it has been impossible to predict with any degree of accuracy the exact amount which will be required before the actual operation of the reheat boiler. As a matter of fact, several cases have been reported to me in the past where initial calculations had indicated that spray-water would be required, and where actual operation proved that reheat temperature remained within the prescribed limits without any injection.

* Consulting Engineer and Manager of Planning, Harrison Div.

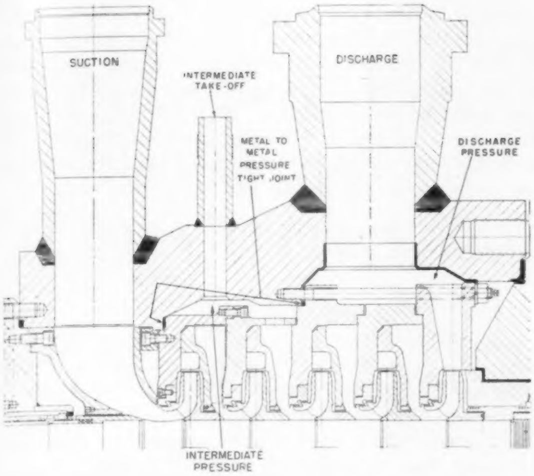


Fig. 1—Tapping an intermediate pressure chamber (in this instance, within the pump casing barrel) is one means of obtaining a source for attemperation.

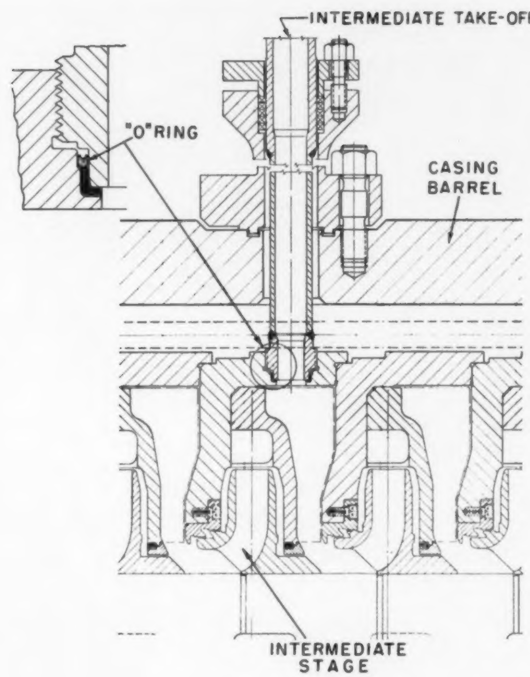


Fig. 2—The method employed in Fig. 1 is hereby attained by drilling the casing barrel for the insertion of an intermediate take-off pipe

Where spray-water is required, the quantities are not particularly large. For instance, a typical 156,000 kw unit, designed for 1800 psi throttle pressure, requires no spray-water until steam flows exceed 400,000 lb hr and the quantity of spray-water increases from zero at that steam flow to 80,000 lb hr at a steam flow of 1,080,000 lb per hr to the boiler.

Whatever the quantity required, we have to provide this water at a pressure sufficient to inject it into the reheat attemperator at all loads. If the reheat pressure at full load is about 450 psi, a pressure of 500 to 550 psi will generally be required to overcome friction losses and the pressure drop through the varporizing nozzle. In some cases, separate spray-water pumps have been provided to supply this demand. In other cases, so as to eliminate the need of two separate pumps (one running and one standby), the required amount of water has been diverted from an intermediate stage of the main boiler feed pumps. Finally, in some cases it was preferred not to complicate the construction of the feed pumps and to take the necessary spray-water from the discharge of the boiler feed pumps.

Tapping an intermediate stage of the boiler feed pump to provide a source for attemperation introduces design complexities which, in my opinion, should preferably be avoided. Nevertheless, a number of installations have been made with this arrangement. Two different solutions have been used to tap an intermediate stage:

1. As shown on Fig. 1, where an intermediate pressure chamber is formed within the pump casing barrel. The inner assembly is bolted against two separate shoulders in the casing barrel, to provide a sealed isolation between the final discharge pressure and the intermediate pressure. This construction cannot be applied to pumps already built and in the field.

2. As shown on Fig. 2, where the casing barrel is drilled for the insertion of an intermediate take-off pipe. This pipe is screwed into a tapped opening in an intermediate stage-piece and leakage is prevented by means of a teflon "O" ring sealing between the pipe and the stage piece. The take-off pipe is attached to the casing by means of a second pipe which contains a stuffing box sealing against full discharge pressure.

While this last arrangement can be applied to pumps already installed in the field, it is my opinion that the alignment of the casing barrel opening and of the drilled and tapped hole in the intermediate stage requires very accurate and careful machining. As a result, it would be preferable to remove the pump from its baseplate to carry out this modification in a machine shop.

When feedwater is taken from the discharge header, we are faced by the serious problem of throttling the injection flow and destroying a very large pressure drop in the control valve. For instance, the discharge pressure of the boiler feed pump may be 2450 psig at full load and it would have to be throttled down to 500 psig—a pressure drop of 1950 psi. At the minimum load condition where spray attemperation is required, the pump discharge pressure may be 2850 psig (if the boiler feed pump operates at constant speed) while the required spray-water pressure may be 200 psig. The pressure drop across the regulating valve will have increased to 2650 psi. No wonder that the life of these regulating valves has frequently been very short and that the cost of maintenance has been high.

There is one arrangement which can be incorporated in the spray-water control system and which is intended to reduce excessive control valve maintenance. The method is based on the principle that breaking down a high pressure differential through several orifices in series leads to less wear than when the same differential is broken down in a single valve. The same orifices are used in this arrangement as the orifices commonly employed to break down high pressure differentials in the

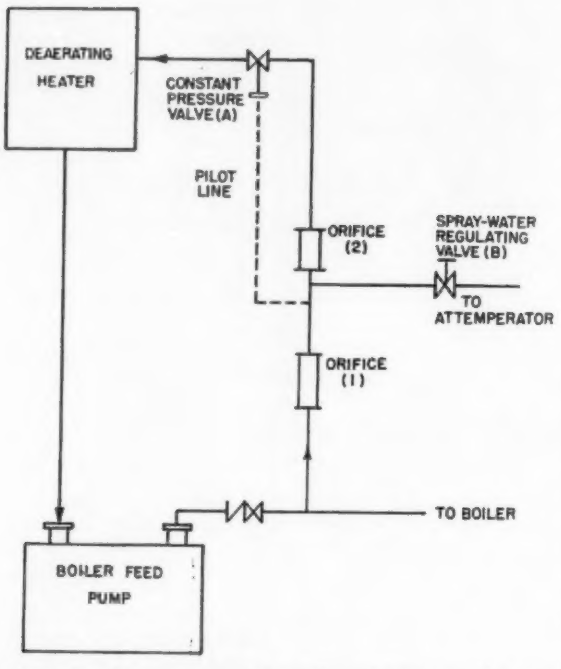


Fig. 3—The above arrangement of an orifice and a valve provides spray water control at the reheat attemperator. This method permits a careful study of attemperator flow requirements and then a separate, properly sized pump can be purchased for this need

recirculation by-pass lines which protect boiler feed pumps against an excessive temperature rise under low flow operation conditions.

The arrangement is illustrated in Fig. 3. The spray-water is taken from the discharge of the boiler feed pumps, beyond the check and gate valves. In a multiple pump installation, this line can be taken from the boiler feed pump discharge header. Two orifices are located in this line, which lead to the deaerating heater at the boiler feed pump suction. A control valve (A) is incorporated in the line, following the second orifice. The orifices and the valve are so dimensioned that the desired spray-water pressure can be maintained under all conditions at a point between the two orifices. The actual flow to the attemperator is then diverted from that point and is taken to the attemperator sprays through control valve (B). This valve is regulated exactly in the same manner as it is now, through a two- or a three-elemet control.

Let us examine the operation of this arrangement under the conditions described earlier in this article. The total flow to the attemperator at full load will be 80,000 lb per hr and the pressure at the point between orifices (1) and (2) will be maintained at 500 psig. We shall further assume that the heater pressure plus static elevation to the heater is 125 psig, that the pump discharge pressures at full load is 2450 psig and that the minimum pressure drop through valve (A) is 50 psi. We can select design conditions for the orifices as follows:

Flow.................................80,000 lb/hr
Pressure drop through orifice
(1)..........................$2450 - 500 = 1950$
(2)...................$500 - (50 + 125) = 325$ psi

Valve (A) becomes a constant pressure regulator, set to maintain a pressure of 500 psig between the two orifices, regardless of the flow through orifice (2). For instance, if the total flow of 80,000 lb per hr is directed to the attemperator through valve (B), valve (A) will close. Assuming that at minimum load sthe back pressure at the heater drops to 75 psig, the maximum pressure drop through valve (A) would reach 425 psi (500 psig − 75 psig). In turn, valve (B) will never be subjected to an excessive pressure drop either, since at reduced loads when the required attemperator pressure drops to 200 psig, the valve will be throttling from 500 psig to 200 psig, or only 300 psi. Thus, these valves will be breaking down a considerably lower pressure than the 2650 psi encountered without the use of orifices and the life of the valves will be extended considerably.

One of the greatest attractions of this arrangement is that it can be incorporated into an existing installation which has been encountering difficulties from the point of view of regulating valve maintenance in the attemperator circuit for the reheater. This solution makes it possible to remedy the difficulties without having to modify the boiler feed pumps themselves.

It is true that there is a power loss attendant to the constant flow of 80,000 lb per hr from the discharge header under reduced load conditions when no attemperation is required. But there is a very attractive solution which combines the use of this orifice in series arrangement and the use of a separate pump designed to handle the attemperation requirements. No such pump is purchased before the plant is started up, so as to be assured first that attemperation flow *is* required and to learn exactly how much will be needed. During start-up operation, the attemperation is provided through the arrangement described on Fig. 3 and careful observations are made of the actual requirements. After this, a single pump is purchased and installed to provide the spray-water. No standby pump is necessary since the orifice arrangement is always available to supply the flow at any time that this single pump must shut down for inspection or repairs.

In our October issue on page 22, due to an unfortunate oversight, the article "A Probe for Studying the Deposition of Solid Material From Flue Gas at High Temperatures" carried the byline of but one author, P. J. Jackson. Actually this paper was co-authored and should have also carried the name of E. Raask, B.Sc., of the Central Electricity Research Laboratories. Mr. Raask is well known for his work in this area and we regret sorely that we permitted this unintentional slight.

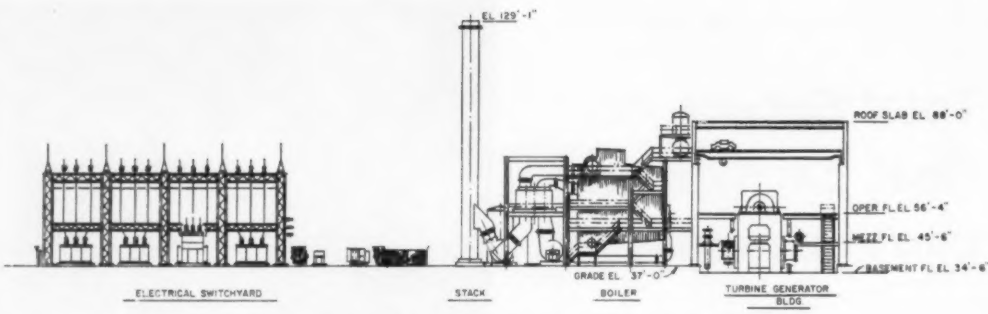


Fig. 2. Cross sectional view of the entire 22 MW outdoor plant

By D. N. HIGGINS*
Brown & Root, Inc.

Record Completion Time for 22 Mw Power Plant

September 12 was the dedication date for the Si Ray extension of the Brownsville Municipal Utilities. Work was completed within seven months from the confirmation of contract. A remarkable achievement and at an equal impressive installed cost of $137.34 per kw.

NEAR the exit of the Rio Grande River into the Gulf of Mexico and serving as a border terminus to Mexico, Brownsville, Texas, is situated at the crossroads of the rich Rio Grande Valley. It is serviced by principal railroad and highway systems, and has direct access for major shipping from the Port of Brownsville to the Gulf by ship channel. The Rio Grande Valley is growing rapidly with the development of the river, both in industrial installation and in reclamation of rich farm lands by irrigation. Along with its growth there is an increased dependency on the facilities of the Brownsville area. The electric load growth alone is in excess of 14 per cent annually. This has led to a critical demand for increase in electrical generation by the Electric Power Utility. It became apparent in the summer of 1960 that additional power must be available for the summer peaks of 1961.

Project clearance for an addition to the existing generating facilities was authorized Nov. 1, 1960. A study indicated that the optimum extension to existing facilities would be a 22 Mw steam turbine generating unit. A contract for engineering, design and construction, and the furnishing of all equipment and material was awarded to Brown & Root, Inc., Nov. 29, 1960. The contract called for a complete semi-outdoor generating plant, to be in commercial operation by July 1, 1961. Obviously such a schedule would be impossible unless a boiler could be found for immediate shipment and a turbine generator available for complete delivery at site by May 1, 1961. These units were located and releases obtained from the manufacturers. A construction schedule was prepared for on line availability of power by schedule date (see Fig. 1).

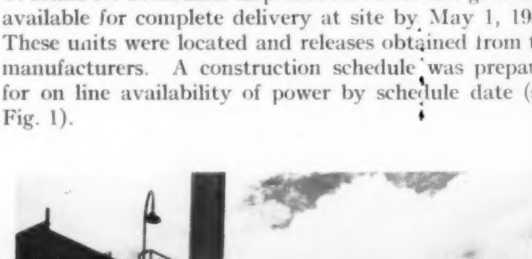


Fig. 3 Exterior view of the boiler and in the background the turbine room of the station

* Chief Power Engineer.

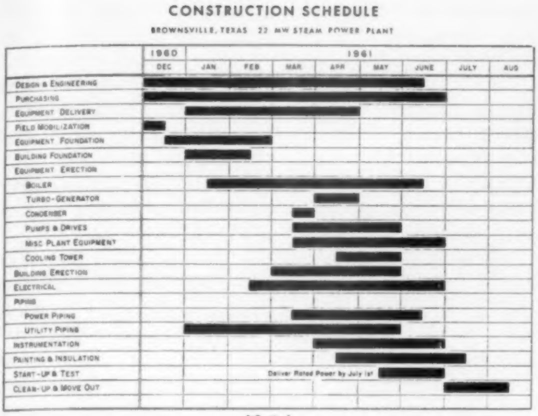


FIG. No. 1

Fig. 1 Construction schedule, above, is broken down by major areas of action. You will note many overlap and several items arriving at a relatively late date required very early ordering

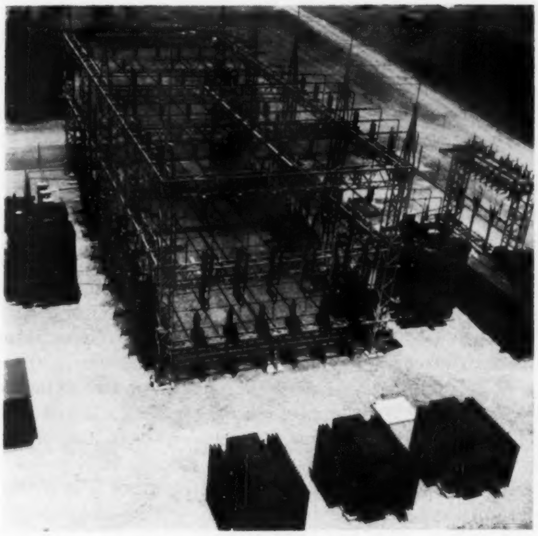


Fig. 4. Aerial view of the completed 55Mw substation and authorized at a cost of $10.03 per kw

Actual work at the job site was begun Dec. 2, 1960. Preliminary investigation of equipment availability by Brown & Root, Inc., prior to submission of the bid proposal, had established competitive equipment sources. An accelerated purchasing schedule enabled placing all major equipment on order by Dec. 5, 1961, and establishing equipment delivery dates which would substantiate the previously established construction schedule. Engineering in the form of soil studies, foundations, equipment layouts, architectural renderings, and system flow sheet was begun immediately. A subsequent "Lump Sum" contract for a switchyard and substation was issued to Brown & Root, Inc., in February 1961, for availability concurrent with completion of the contract for the power generating facility.

The general plant extension and heat balance were, for the most part, standard for a unit of this capacity and presented few unusual design problems. The basic project considerations were resolved to insuring delivery of equipment and material to meet field erection schedules, and to an accelerated construction program during adverse weather conditions of the winter months, all dovetailed to meet an operational availability so brief for a plant of this type that it is considered unique.

On June 26, 1961, the installed unit was operated commercially at 25.5 Mw. Based on this proved capability, the total installed generating cost, including engineering and start-up as well as equipment and construction, was $137.34 per kw. The switchyard and substation, designed for a total of 55 Mw, was completed at an installed cost of $10.03 per kw. It is noteworthy that these unit costs are well below the national average for installations of this size, and that a well designed and fully operable plant, utilizing the highest quality equipment, was completed without penalty to owner or contractor in the short project time available. Figs. 3 and 4 show an exterior view of the completed plant and switchyard on July 26, 1961.

Si Ray Extension

Prior to the addition of the new 22 Mw unit, the generating facilities consisted of five units totaling 30 Mw. The station was of the indoor type, located in a steel, concrete and brick building. The 22 Mw Si Ray Extension to this station is semi-outdoor design, with boiler and auxiliaries located outside, Fig. 3. All are provided for operation at turbine-generator unit capability.

The available boiler was a balanced draft unit, originally provided for outdoor installation in the tropics, and designed for residual fuel oil firing. By changing burners the boiler was converted to gas firing, with provision for light fuel oil emergency firing. These new burners were of the gun type and could be changed to and from either fuel oil or gas without shutdown or drop in load. A new and larger regenerative air preheater was provided, together with new and larger forced draft and induced fans. Predicted data for gas firing set maximum continuous rating of the boiler at 235,000 at 900 psig and 900 deg FTT at the superheater outlet, with a peaking capability of 247,000 lb per hr. After development of the heat cycle, the temperature and guarantee points were set at 215,000 lb per hr at 900 psig and 900 deg FTT, which matched turbine generator requirements for 25 Mw at 850 psig and 900 deg FTT at throttle inlet. Forced draft fan is controlled by inlet vanes, and induced draft unit by outlet louver dampers. Both fans are provided with motor drives capable of continuous operation at fan test block conditions which is more than ample for peaking capability. Noteworthy is the fact that the boiler manufacturer accomplished all these changes on an accelerated schedule and fulfilled the required shipping dates. Boiler drums and tubes were received on the job Jan. 15, 1961, and the lower drum was set the same day. All other parts were received on or before the dates required in the field, and the boiler was ready for commercial operation June 10, 1961.

Turbine-generator is an AIEE-ASME Preferred Standard unit having a generator rating of 29,411 kva, 85 per cent power factor and 0.64 short circuit ratio, with turbine designed for full kva output at 850 psig and 900 deg FTT throttle steam conditions. The tur-

bine and generator are each of the latest design, incorporating features to improve operating economy and availability. The generator was shipped prior to the turbine and was partially set and aligned on foundation before arrival of the turbine. After factory test, turbine parts were shipped in special groupings and according to a schedule which would facilitate delivery at the job site to best suit expeditious erection. Erection proceeded on schedule without interruption and the unit was in service at 25.5 Mw load June 26, 1961.

The plant cycle is conventional regenerative, utilizing all four bleeder openings provided on the turbine. Three closed heaters and a deaerator are provided for boiler feedwater heating. Heater Number 1 is a horizontal unit with integral drain cooler and is mounted at mezzanine floor elevation to insure gravity drain to condenser at low loads. Heater Number 2 is a vertical unit and includes drain cooling zone, drains cascade to unit Number 1 and back to condenser. Deaerator is at Number 3 bleed point. High pressure heater Number 4 is a vertical unit and includes desuperheating zone and integral drain cooler. Drains from this unit return to deaerator. All heater drains are handled by the conventional level controls and valves. Level alarms are provided on boiler control board. Feedwater temperatures are recorded continuously in the control room for several points in the cycle.

Deaerator is rated at 250,000 lb per hr and is located outdoors over the boiler firing aisle, at an elevation sufficient for adequate NPSH on the feed pumps under normal and adverse transient conditions. Deaerator overflow is routed to the condensate storage tank. Demineralized make-up water is added at the condenser for partial degassification before entering the heaters.

Two full-size vertical hotwell pumps are provided, each having its own suction line to the condenser storage hotwell. Pumps discharge through the air ejector condensers, and heaters Number 1 and 2 to the deaerator.

Two horizontal, split case, eight-stage boiler feed pumps are provided. Each is equipped with mechanical seals and shell and tube oil coolers, and has a capacity to handle in excess of 18 Mw plant output. Each feed pump arrangement is also equipped with automatic minimum flow control and warming provisions which allow instant start-up from control room.

Condenser is a two-pass, divided water box, low head room unit, having 25,000 sq ft surface. Tubes are Admiralty and are $^7/_8$ in. diameter by 22 ft long. Unit requires 30,000 gpm of cooling water, which is provided by two vertical mixed flow pumps, each rated at 16,500 gpm at 70 ft head. These pumps also provide hydrogen, oil, and miscellaneous equipment cooling. An auxiliary vertical cooling water pump of 3000 gpm capacity is also provided for equipment cooling, with automatic start on cooling water pressure drop. These three pumps are located in a pump pit adjacent to the boiler stack. Circulating pumps are control room operated.

Noteworthy is the fact that the condenser was shipped over 1800 miles in four pieces, with tubes rolled in at the factory to facilitate field erection. After installation and test, only three tube ends were "touch-up rolled" to correct "weeping."

Feedwater Treating

Consideration was given to both evaporation and demineralization of boiler make-up water. Evaporators were in use on the largest unit of the old plant, and were satisfactory under most operating conditions. A dependable raw water supply is available from the municipal system. Although the dissolved solid content of this water is exceedingly high in silica and sodium chloride content, demineralization was chosen for this unit because of the inherent flexibility of this type of treatment.

A two-bed cation-anion unit to remove the majority of the salts, followed by a mixed bed polishing unit to insure maximum purity of boiler feedwater, was used.

The primary units are oversized to allow for high flow rates during initial start-up, and longer runs between regenerations. Normal make-up requirements are expected to be approximately 4 gpm. However, the demineralizer can handle flows up to 15 gpm. In order to maintain a minimum flow rate through the demineralizer at all times to prevent poor quality water, recirculation pumps are included to continuously recirculate 10 gpm from the effluent of the mixed bed unit to the inlet of the two-bed system. During the initial start-up these pumps were not operated, and the entire 15 gpm flow was passed to the treated water storage tank.

Both the two-bed and the mixed bed demineralizers are furnished with push button automatic regeneration controls, requiring manual initiation of regeneration. Alarms and shut-down valves are supplied to shutdown the system after passage of pre-set amount of water or poor quality effluent.

Standard packaged design components were utilized for all units to speed engineering and delivery.

Plant Cooling Water

For a power plant of this size, the characteristics of the Rio Grande River at Brownsville were not suitable for once-through power plant cooling purposes without storage and recirculation. Because of this, two ponds were created by dyking areas adjacent to the river. The larger pond has an area of approximately 30 acres and averages about 6 ft in depth; the smaller pond has an area of approximately 2.8 acres and a depth of 6 ft. These ponds serve a dual purpose—to provide a reservoir for raw river water storage for municipal water supply, and to provide cooling water for the power plant by recirculation and dissipation of heat from the pond surface. Make-up water is pumped to these ponds from the river as required. These two ponds served the initial plant through its growth to 30,000 kw, and had reached their limit for satisfactory cooling purposes. The addition of the new unit necessitated additional cooling water facilities. Additional pondage was impractical if not impossible at this location, and it was decided to utilize a cooling tower, Fig. 5. Area conditions dictated the installation of the tower over a portion of the smaller pond as a basin, and the construction of a new and separate water intake for the 22 Mw unit.

A three-cell, double-flow, induced draft, transite cased cooling tower is provided and rated at 33,000 gpm, 105 deg water on and 90 deg F water off at a wet bulb temperature of 80 deg F. The cooling tower and piping are supported on treated timber pile at a corner of the 2.8 acre pond. The cooling water circulating system is independent of the older plant, except that part of the pond which acts as a basin for the cooling tower. Cooling water circuit is 2000 ft from circulating pump discharge, condenser, cooling tower and back to pump pit.

Fig. 5. A three cell, double-flow induced draft transiste cooling tower is featured

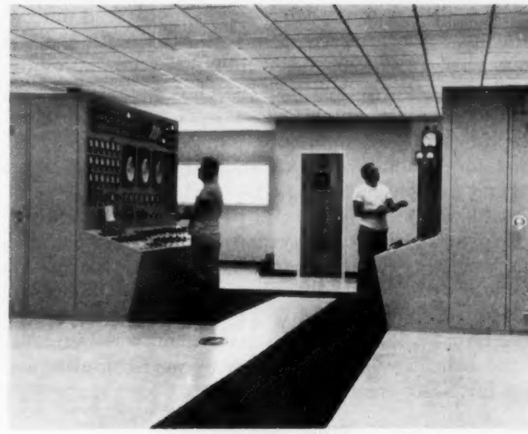


Fig. 6. Air conditioned control room now handles only the new unit the switchyard and distribution system

Controls and Instrumentation

The air conditioned control room was designed to serve as a central control room for the initial plant as well as the new 22 Mw addition, and a future unit of 22 Mw or larger. Presently only the controls for the new unit and the electrical switchyard and distribution system are located in this room (see Fig. 6).

Boiler, turbine, generator, auxiliaries contiols, and turbine and other supervisory instruments are all mounted on one control board. Control system for the boiler is a standard pneumatic conventional metering type, with three-element feedwater control system. Interlock devices are incorporated with the combustion control system for boiler firing and safety shutdown.

Combustion controls are designed for gas firing by either manual or automatic control from central board. Light fuel oil firing is for emergency only, and is remote manual control from central control panel. It can also be used in combination with manual gas operation. Burner ignition is local with flame rod pilot scanning.

Spring loaded and remote actuated gas minimum burner pressure control valve is incorporated in design for boiler start and minimum flame control. Bench front duplex panel in control room incorporates control switches for motors, giving operator control of unit auxiliaries from control room. Generator control switches are also located on same panel. A duplicate panel, located across the aisle, incorporates all electrical controls for the switchyard and distribution system. Local panels are installed for information and control at burner level for boiler start and at the turbine level for turbine start.

The arrangement of the control board makes it possible for one operator to handle the new unit as well as the electrical distribution system.

Electrical System

Three-phase bus duct is installed to connect the generator terminals to the surge protective switchgear, which is located on the mezzanine floor. From the surge protective switchgear, 15 kv cable leads are run in cable tray and underground ducts to the 30 mva FOA 13.2–69 kv step-up transformer in the switchyard. Since a new 69 kv distribution system was planned, a new switchyard was built to step up generation from the existing generators as well as the new unit. The switchyard consists of seven 69 kv oil circuit breakers in a double-bus arrangement, the 30 mva transformer, and a 20-unit 15 kv outdoor metal clad switchgear throat connected to a 25 mva step-up transformer.

The generator and its auxiliaries are controlled from the boiler-turbine-generator board in the control room. The board is a walk-in duplex type with relays and recording meters on the back. Mimic bus is used to graphically show the switchyard buses, feeders and tie lines.

A fan-cooled switchgear room contains the 2400 volt and 480 volt load centers which supply control for the large and small auxiliary motors. Cable trays as well as rigid conduit are used for routing the power and control cables.

Station Structures

The initial plant is an indoor type, and is housed in a brick and concrete structure with a temporary end wall of transite to allow for plant expansion. Because of the additional erection cost and the time limitations, the 22 Mw addition is of semi-outdoor design; i.e., the boiler and its auxiliaries and the deaerator are outdoors and the remainder of the equipment is housed in an extension to the existing plant turbine room bay. The bay for the new unit was designed to provide the operating floor at the same elevation as the original, and to allow use of the existing 25-ton crane. Turbine bay extension is 80 ft long by 56 ft wide by 53 ft 2 in. high from finished basement floor to roof. This structure contains 9.62 cu ft per kw capability. An air conditioned control room for the extension as well as the initial plant is also provided. The air conditioning unit is a "heat pump" providing cooling and heating automatically as required. Control room bay, at right angle to turbine bay, is 32 ft wide by 62 ft long by 38 ft 2 in. high from finished basement floor to roof, and contains 2.95 cu ft per kw capability, new unit only. The mezzanine floor below control room proper carries all switchgear for the new unit, and basement floor below mezzanine carries boiler feed

pumps, compressors, air drier, and chemical feed pumps.

The plant is located on a former bed of the Rio Grande River. Soil conditions necessitated the use of piling, and all piles develop their load carrying capacity through skin friction. One hundred sixty-six (166) poured-in-place concrete piles approximately 54 ft long were required for building, equipment, and circulating water pump pit foundations.

One hundred forty-one (141) treated timber piles were required for cooling tower, circulating water return line, transformers, switchgear and substation. Excavation was completed and pile driving under building, boiler and stack foundations was started Dec. 19, 1960, and completed Dec. 28, 1960. First concrete pour was December 31, and boiler and stack foundations were complete and ready for boiler erection, which started Jan. 15, 1961.

Plant Start-Up

Plant start-up was trouble-free and without incident. Check-out of each item of equipment, washing of piping and boil-out of boiler were started May 25, 1961. Demineralized water and condensate from the old plant were used for flushing and washing of equipment and piping. The turbine-generator unit was started and checked, and on June 10, 1961, was synchronized with the system and loaded to 10 Mw. On June 26, 1961, the unit was operating at 25.5 Mw. During initial operation the use of demineralized water for cleaning "paid off," and the silica was well within permissible tolerance.

Conclusions

The completion of the total project in less than seven months from confirmation of contract, and at the low installed cost of $137.34 per kw, was made possible through the following general factors:

1. Placing of responsibility for engineering, equipment, and construction in a "lump sum" with one contractor, experienced in this type of work and already staffed to handle all phases.

2. An accelerated program of engineering, which was at least two weeks ahead of any corresponding phase of construction.

3. Continuous and effective liaison between field and engineering personnel.

4. Establishing competitive sources of equipment and materials, and a rigid system of material control and expediting, which insured that all items would be delivered on or ahead of schedule.

5. The cooperation and active interest of the various manufacturers. Design drawings were available almost immediately on issue of equipment purchase orders. Vendor shops maintained a constant check to insure coordination and minimum time loss in fabrication. Where possible, administrative procedures were modified to cut time lag in processing, and in some cases special shipment was employed.

6. The cooperation of the railroads and trucking organizations in the routing and handling of shipments of equipment and material to the job site. These companies diligently followed the progress while en route and there were no transportation delays.

A final factor of paramount importance was the swift design approval and active assistance of the Utility Board, represented by Mr. George K. Weir, Manager.

USSR Power Plants Using TV Monitoring Systems

Every major power installation in Moscow and its outlying areas will be using closed-circuit TV systems for monitoring instruments by 1965 if the present plans of Soviet authorities develop according to schedule, a Moscow technical journal reports. But an anticipated "significant improvement" in Soviet telemetering techniques is contingent upon efforts to overcome the USSR's current lag in constructing radio-relay lines, the Russian periodical *Electric Power Stations* notes.

The report from *Electric Power Stations* is included in a collection of 10 articles on Soviet precision equipment—compiled from various USSR periodicals—available in English through the Office of Technical Services, Business and Defense Services Administration, U. S. Department of Commerce, Washington 25, D. C.

Five years ago, the Moscow Regional Power System Administration began experimenting with closed-circuit TV monitoring devices, according to an article in a recent issue of the USSR periodical *Electric Power Stations*. The article's analysis of the data compiled during these tests noted that "in the case of the turbine shop of a power plant . . . the image shown on the TV screen was completely satisfactory, and all arrows, scales, and curves on the recording instruments were clearly visible." In monitoring "the escape of steam from the turbine's overflow tube, the quality of the image made it possible to evaluate the condition of the packing," says the Soviet report.

Although the article admits that these 1956 experiments revealed some inadequacies in the Soviet monitoring techniques, the test results were good enough to convince Russian power authorities that they were fully justified in further research and development. During the first tests, "the water-gauge column (in the boiler shop) was kept under observation, and the image permitted evaluation of fluctuations in the water level." But the researchers found that "this image proved to be unsatisfactory because of fouling on the glass of the column and inadequate illumination,"

Initial Soviet experiments in monitoring furnaces were also unsatisfactory, the article notes. The TV cameras aimed "through existing inspection hatches . . . showed the illuminated outline of the hatch, and this illumination varied as the flame-burning regime underwent change." However, "such observations were not adequate." It then was decided, according to *Electric Power Stations*, to use "a periscope which can be introduced directly into the furnace."

"A special panoramic periscope hooked into a TV camera . . . can be moved in and out to an inspection window built into the wall of the furnace; in order to cool the periscope, a water sleeve with circulating water has been provided." This cooling system, the article points out, "makes it possible to keep the combustion process (for a period of 20 minutes) under continuous observation."

Twenty Second Annual International Water Conference

The Engineers' Society of Western Pennsylvania successfully ran another in their long string of well attended, well handled Water Conferences Oct. 23–25 in Pittsburgh, Pa. Here are abstracts of papers held to be of interest to power field readers.

Boiler Water Carryover

P. M. Spurney and **S. O. Meyer,** Betz Laboratories, Inc., joined forces to open the Water Conference with the paper "Experiences in Detection of Minute Amounts of Boiler Water Carryover Using a Portable, Continuous Recording Sodium Tracer Apparatus." The authors pointed out early in their paper that most of the knowledge of the sodium test as a method of evaluating steam purity had been based heretofore on laboratory data. Now it can be clearly demonstrated that the sodium content of a continuously flowing condensed steam sample can be done in the field in a very practical and efficient way. The equipment involved is portable, namely a Model B Beckman Flame Spectrophotometer and a Varian Model G 11 A Strip Chart Recorder. This the authors demonstrated by slide views.

After a brief description of the principle of operation Messrs. Spurney and Meyer reviewed several plant studies. In one instance, a chemical plant, the average conductivity values indicated a calculated solids content consistently less than 1.0 ppm and probably averaging about 0.5 ppm. Yet turbine deposits were of such a magnitude that the turbines needed water washing every 5 to 6 weeks. With the portable equipment herein discussed spot samples as well as continuing samples could be taken at individual sampling points. This revealed a marked variation in steam purity from the sampling points and steps are underway to install additional steam purification equipment.

Similarly other case studies supported the authors' contentions that a means of rapid, portable testing of either spot or continuous condensed steam samples permitted pinpointing otherwise obscure trouble spots.

This last named feature of alternate continuous or spot sampling has made it possible to monitor a condensate stream which is a composite of many sources, any of which may be introducing contamination.

Cooling Water

"Investigation of Polyphosphates as Corrosion Inhibitors in Cooling Water Systems" was the selection of **Herman Kerst** and **Richard G. Dalbke,** Dearborn Chemical Co. Langelier successfully worked out the complex system of equilibria relating the various parameters of calcium, phosphate and polyphosphate ion contents, temperature and pH for the control of calcium carbonate deposition. No such a solution has been developed as yet for the deposition of calcium phosphate. As a result the authors have been studying the use of polyphosphates as corrosion inhibitors for steel in open recirculating water systems especially with the aim of developing agents to minimize calcium phosphate deposition.

A simulated testing tower was set up using water equivalent to Chicago city water concentrated eight times. Specimens were 1 by 2 in. S.A.E. 1008 cold rolled steel, sandblasted and acid etched before use. Comparisons between inhibited and uninhibited waters have been made to establish the efficiency of inhibition under various conditions. Plots of data were presented and certain generalities were offered from both laboratory and field investigations.

The percentage inhibition of corrosion provided by polyphosphates increases as the temperature is increased. The higher molecular weight linear phosphates give better corrosion control than do the lower molecular weight types. The data at hand for various added metallic ions such as zinc do not show agreement with earlier published work. However, the field studies of the minimum levels of polyphosphate residuals needed for effec-

tive corrosion control in circulating waters of this type did agree with previously published data. Sodium polyphosphate incorporating zinc is a superior corrosion and deposit inhibitor to polyphosphates not including this metal ion. Furthermore the corrosion and deposit inhibiting properties have been further improved by the use of organic synergists.

C. W. Regutti, Hagan Chemicals and Controls, Inc., together with **T. H. Power,** Gulf Oil Corp., followed with their paper "Cooling Tower Preservation by Steam Sterilization and Chemical Distillation—A Progress Report." This newly developed process aimed at controlling fungal growths occurring deep inside wood is essentially a combination process. First all the wood is sterilized by steam and then a surface layer of fungicide is applied by means of steam distillation.

All or part of a cooling tower is covered with a tarpaulin, plastic or water-proofed paper or other material which will hold steam. The steam is then injected into the tower to heat up the wood and hold it at a sufficiently high temperature for a long enough period to kill all the fungi inside the wood. Some steam is then bypassed through a pressure vessel containing the fungicidal agents. The chemicals are then steam distilled into the cooling tower and are condensed and absorbed upon contacting the wood especially as the tower temperature cools. The authors then described an actual field application.

Chemical Cleaning

D. B. Carroll, C. L. Eddington and **J. P. Engle,** Dow Chemical Co., opened a full morning session on chemical cleaning with the paper "Chemical Cleaning With Foamed Solvents." The physical properties of a dynamic foam cleaning system are intermediate between a gas and a liquid. Because it is a relatively new technique the authors thoughtfully supplied the following as an introduction.

"If we fill a tube containing mill scale on the interior with hydrochloric acid, the mill scale is readily removed. We can take a portion of this same unused solvent, convert it to a good stable foam and slowly pass the foam through the tube and, again, the mill scale will be removed. By this simplest experiment, however, we have found out several things which were not readily apparent. First, in order to obtain satisfactory cleaning, the foam must be kept flowing through the tube. The liquid solvent in one bubble contacting the deposit is not enough to clean completely and soon becomes spent. Therefore the spent bubbles must continually be replaced with new bubbles. Foam cleaning, then, is a dynamic system and cannot be applied by a simple fill and soak technique. Yet this dynamic system affords a complete sequence of cleaning, flushing, neutralization and passwater."

Because of the physical nature of the foam under some conditions a far less solvent volume of acid is needed than is so with a liquid solvent. Sand and debris particles exposed to the sweeping action of the moving foam are a bonus removal item with this technique.

The authors then turned to a more detailed description of the physical and chemical properties of a desirable cleaning foam supported by pilot plant and field study data. As a result of the success of these studies and field applications the authors see this cleaning method as an attractive one for superheater tubes or for the steam side of condensers.

P. L. Silliman, Consolidated Edison Co. of New York, in his comments described his company's experiences with the foam cleaning of several steam condensers, giving certain back-up data. With each successive cleaning condenser performance approached more nearly to design conditions. Moreover, Mr. Silliman pointed out, there were some advantages not expected. In the case of liquid solvents there have been difficulties in the past in holding the solvent for the required cleaning period. Circulating water butterfly valves had to be sealed off by caulking or blocked off by temporary brickwork. This has been eliminated with foam cleaning.

Con Edison, it was reported, has been reluctant to try foam cleaning on the steam side of the condenser for fear that the foam might not be entirely removed with possible subsequent damage to equipment and also to the possible foaming of boiler water.

The second paper of the three-paper session "Chemical Removal of Magnetite and Copper" was presented by **S. Alfano,** Houston Lighting and Power Co., and **W. E. Bell,** Chas. Pfizer and Co. Because of the fine results with citric acid in the preoperational cleaning of units containing austenitic steels investigations were set under way to use this same acid as a solvent for operational deposits. A method based on the use of ammonium citrate solutions has resulted from these investigations. It is this method that makes up the paper.

Briefly stated the method consists of filling the unit to be cleaned with a dilute solution of ammonium citrate under slightly acidic conditions (pH 3.0–5.0) for a short period of time, followed by treating this same solution with additional ammonia (pH 9.5–10.0) and an oxidant in order to complete the removal of metallic copper. The acidic solution dissolves the magnetite, and destroys the attachment and adherence of the deposit to metallic surfaces. The alkaline solution dissolves the metallic copper, and stabilizes the dissolved copper as copper ammonium complexes. Thus, a single solution may be used to obtain complete chemical cleaning and leave behind a surface capable of resisting reoxidation even in moist atmospheres. The authors give the chemistry of this process in fair detail and also supply information from actual operating units including controlled circulation and natural circulation boilers.

W. B. Willsey, Philadelphia Electric Co., pointed out the apparent improvement from this method—a saving of down time, with the continuous two phase treatment rather than two separate operations for copper and iron removal, and a superior solvent action especially where austenitic materials are present. Yet the absence of any inhibitors with the ammonium citrate cleaning prompted Mr. Willsey to conduct a laboratory test which he gave in detail. This test convinced him that there was a dangerously high corrosion rate problem which should be further worked on before widespread application of

what appears to Mr. Willsey to be an otherwise valuable procedure.

Stanley M. Rose and **W. F. Ashton,** Sumco Engineering, Inc., then presented their paper "Chemical Cleaning of Boilers and Auxiliaries by the Sumco Hi-Flo Method." The basic theory and field applications of the method herein described were presented before the ASME at the December 1960 Annual Meeting in Paper No. 60-WA-219 entitled "Acid Cleaning of Superheaters and Reheaters." This discussion goes beyond this and treats in a broader scope the following areas of interest (1) superheaters and reheaters (2) condensate and feedwater systems (3) natural circulation boilers (4) once-through boilers (5) surface condensers (6) stage heaters.

Henry J. Vyhnalek, Cleveland Electric Illuminating Co., opened his comments with the statement that the introduction of non-drainable superheaters and reheaters, and monotube boilers has given a significant impetus to circulating solvent cleaning. There is, of course, as Mr. Vyhnalek points out, a tremendous number of highly successful fill-soak cleanings now on record. Without cause no one is likely to abandon a proved system. Yet the non-drainable equipment and the use of parallel circuitry in the newer units compels both the user and the chemical cleaning industry to pursue other techniques such as the authors' company employs. There are, he cautions, control and cost problems involved.

Frank R. McLean, consulting engineer, felt that much of the responsibility for the removal of mill scale, at least, should rest with the fabricator. In the case of condensers this procedure has been specified by Mr. McLean's firm. His own experience with the method the author describes was that it did a much better job with stage heaters, that operational flows could be simulated and an active flow insured through all tubes. Special connections, however, are usually required and he recommends that these connections and their appropriate piping be provided when the equipment is being installed.

Mr. McLean then gave a brief description of the cleaning of superheaters and reheaters by the Hi-Flo Method under his direction. The results were excellent and the only provision Mr. McLean volunteered was that suitable connections be provided to permit an adequately high flow of solvent at least equal to that of the boiler feed pumps at full load.

Condensate Cleaning

The first paper of a three-session meeting was prepared by **William Richardson,** Pennsylvania Power Co., and **Eugene D. Driscoll,** The Permutit Co., and entitled "Demineralizing Experiences at Pennsylvania Power Co." and more specifically the 1958 installation of an automatic demineralizing plant for this system's New Castle Generating Station.

The authors described the nature of the river water that served as a raw water supply and hence dictated a complete pretreatment before its introduction to the demineralizers. The demineralization system is a 4-step arrangement wherein the effluent from the cation exchanger entered an anion exchanger (the primary units) followed up by a similar set of exchangers (the secondary units). An additional battery of two exchangers works in parallel with the secondary units.

As of June 1961 each of the demineralizing sets has been in service 34 months and served about 40 million gallons of water through 180 operating cycles with no noticeable deterioration of resin capacity. The results were and have been excellent with an effluent with a conductivity below one micromho, and silica below 0.01 ppm.

C. A. Kochanowski, St. Joseph Lead Co., discussed this paper on the basis of his firm's experience with a similar although smaller demineralizer (40 gpm). Mr. Kochanowski's demineralizer receives plant drinking water, chlorinated but otherwise untreated raw water. Chemical costs for demineralization over a 40 month period have amounted to about $1.20 per 1000 gallons which includes all maintenance, chemicals, water analyses and operating labor. The incremental cost for additional flow would be about 60 cents per 1000 gallons Mr. Kochanowski estimated.

John J. Quinlan, Croll-Reynolds Engineering Co., followed up with the paper "Condensate Filtration Equipment Design and Operating Results in Central Station Plants." The heart of this paper was the relating of a number of design criteria for pressure precoat filtration equipment as applied in the filtration of boiler condensate. The author felt that the value of the precoat filtration approach had been well established from the pioneering study days before the Ohio Power Co.'s Philo Unit No. 6 went into service and carrying on to a successful operating record on this unit.

There are some seven highly important factors on the performance and suitability of filtration equipment that have not in the author's opinion, received sufficient attention in the literature. They are: (1) selection of inlet pressure conditions (2) strength considerations in design of filter internals (3) effective precoating—its value (4) selection of grade of cellulose filter-aid material (5) removal of entrapped air (6) in place cleaning of filter-aid material (7) characteristics of filter size. Each of these points have been amplified with some special attention to their effect on improving the overall performance of the filter installation.

E. L. Knoedler, S. T. Powell Associates, in discussing Mr. Quinlan's paper immediately went to the consideration of certain of the amplifications the author made on various of his seven points, for example the point that pump selection under item (1) above will permit extending filter cycles. Mr. Knoedler feels that once the pressure drop across the filter shows an appreciable rise the rate of increase develops so fast that the period of further possible filter operation before the drop is too great is a very small percentage of the filter's cycle. Rather, Mr. Knoedler suggests, selection of inlet pressure conditions

may basically be one of pump design and economy rather than length of filter run.

Another of Mr. Quinlan's seven points of consideration discussed by Mr. Knoedler was that of recirculating precoat slurry. His fear is that some of it after passing through the filter may settle out at the bottom of the element under precoat velocity conditions. Once the unit goes back into service under much higher flow rates this slurry may be stirred up and carried over into the cycle.

Scavenging filters, Mr. Knoedler felt, should be provided with adequate instrumentation to help locate and understand operating problems. There were also several other suggestions and comments offered.

E. B. Morris, American Electric Power Service Corp., expressed the convincing results from visual demonstrations of precoating techniques and cake removal characteristics which Mr. Quinlan had described. As part of his discussion Mr. Morris displayed a characteristic curve of a condensate polishing filter for the parameters of "crud" removal efficiency and for delta P with respect to time, or length of run. He emphasized that the curves were built up from partial test data and as such his discussion might be regarded as either typical or hypothetical—either would apply. He then discussed the curves and the tests that had produced them.

W. H. Frazer, Infilco Inc., supplied as his paper "Operating Data on High Flow Rate Condensate Polishing Without Filters." In setting the background for his subject Mr. Frazer stated that the very little progress that has been made in developing equipment suitable for high temperatures and pressures has forced current practice to compromise with the ideal by polishing condensate as it leaves the hotwell and then taking all reasonable precautions to avoid recontamination in the feedwater heaters and piping. There are wide differences of opinion regarding important details such as how much condensate should be polished and how it should be done since there are less than a dozen large scale condensate polishing plants in operation and most of them have been operating less than a year. This paper dwelt on operating data with high flow rate externally regenerated demineralizers without filters and its purpose, Mr. Frazer stressed, was to advance the industry, not to prove that only one system will do the job.

The author then gave in considerable detail the experiences at the Dresden Nuclear Station of Commonwealth Edison Co., the first large scale high flow rate externally regenerated condensate polishing system without filters. Some further information was given on a second such system now just going into service.

Dissolved Oxygen

"Removal of Dissolved Oxygen From Water—Laboratory Evaluation of Various Adsorption Methods" was presented by **I. M. Abrams** and **R. P. Breslin,** Chemical Process Co. The advent of the boiling water nuclear reactor made the previous methods of oxygen removal—mechanical deaeration or chemical additors—inadequate. Since 1949 some fifty different species of weakly basic anion exchange resins impregnated with some metal, usually copper, have been developed to answer this need. In general they are referred to as electron exchange resins although the author feels they should be more properly classified under the term of redox exchangers. Five of these resins were then singled out for the purposes of this paper.

Experiments were run under laboratory controlled conditions and test data was accumulated on copper leakage and its effect on pH, iron and manganese leakage, higher flow rates, low oxygen influents. The copper-amine and the strong base anion-sulfite resins emerged as the most effective.

J. K. Rice, Cyrus Wm. Rice and Co., in discussing the paper recounted how one particular resin was employed in a bed before the polishing demineralizer and results were quite good.

C. Donald Bach of Wallace and Tiernan, Inc. gave a paper whose title is self explanatory—"Wallace and Tiernan Continuous Dissolved Oxygen Analyzer." Measurement is accomplished by an amperometric cell whose current is directly proportional to the dissolved oxygen in the sample water. A sampling cell unit contains the hydraulic components needed for control of temperature, flow, and conductivity of the sample. An indicator transmitter, located in a separate housing, contains the required electrical circuits and an indicating meter calibrated from 0 to 25 pph dissolved oxygen. Any standard millivolt recorder is said to be useable.

H. G. Neill, Philadelphia Electric Co., and **Henry Peterson,** Duquesne Light Co., then told how their companies had been asked to put in sample units for field testing. Results, while encouraging, were inconclusive mostly because of shakedown problems.

Coagulant Coatings

G. R. Bell, Johns-Manville, gave the paper "Coagulant Coatings Open New Applications to Filter Aids." As the author points out the use of diatomaceous silica filter aids for direct filtration has generally been confined to surface waters of relatively low turbidity. This is due to the fact that these filter aids affect turbidity reduction by substantially mechanical means, the degree of removal of any specific particle size distribution being a function of the porosity or grade of filter aid used.

By contrast, filter aids in which the individual particles have been coated with a surface active coating, such as aluminum or ferric hydrate, have substantial adsorptive activity. Their use not only results in a much higher degree of clarification but also affects substantial color and bacteria removal. Interestingly, coated filter aids seem best adapted to more turbid supplies than can be effectively clarified by uncoated filter aids.

Large scale utilization of coated filter aids has not been feasible until means were developed for forming the coatings in the filter in its operating place or at the time of the filter's use. Today this can be done and the paper describes how and then furnishes results in field applications.

Abstracts from the Technical Press—Abroad and Domestic

(Drawn from the Monthly Technical Bulletin, International Combustion, Ltd., London, W. C. 1)

Mechanical Handling

Coming. The Automatic Coal Pile. L. E. Stewart. *Power* 1961, **105** (June), 93–5.

Automation of coal handling from the supply point to the boiler bunkers and/or stock pile is discussed and three plants with increasing order of automation described. At the River Rouge plant two operators are required, at Tait station one only and at Portland station the whole operation is automatic after the selection of the rate of feed for each bunker.

Coal—From Mine to Boiler. Handling and Receiving Facilities. A. S. Drummond. *Pwr. Engng.* 1961, **65** (May), 52–4.

The various facilities employed by the Detroit Edison Co. and their power consumption for the unloading of water-borne coal and from railway wagons are described.

Automatic Coal Sampler and Divider. O. Wirthwein. *Mitt. V.G.B.* No. 72 1961 (June), 200–4 (*in German*).

At the Lünen power station an automatic coal sampler has been developed consisting of a slotted case passing to and fro a falling stream of coal and a riffler for subdividing the sample. Extended tests have shown that the samples thus obtained are suitable for the accurate determination of the coal properties.

Investigations into the Transport Process on Vibrating Troughs. Pt. I. K. H. Wehmeier. *Fördern und Heben* 1961, **11** (May), 317–27 (*in German*).

This first part deals with the theoretical side of the problem, such as general considerations of the vertical and horizontal movement of the trough and the material to be transported, the transport speed and its graphical determination and the influence of changes of amplitude and frequency on the speed. The influence of the properties of the material being handled on the transport process is discussed.

Investigations into the Transport Process on Vibrating Conveyors. K. H. Wehmeier. *Fördern und Heben* 1961, **11** (June), 375–83 (*in German*).

This second part deals with the experimental investigations and their results and discusses the reasons for certain discrepancies between theory and experimental results.

Vibrating Conveyors in Coal Pulverizing Plants. J. Hengstebeck. *Mitt. V.G.B.* No. 72 1961 (June), 204–8 (*in German*).

At Hüls power station the coal is transported from the bunker outlet to the downcomers to the mill by horizontal tubular vibrating conveyors of 12.6 in. diam. Each mill has two feeder tubes which can be operated simultaneously or separately and at different feed rates. They contain instruments indicating stoppage of coal flow. The control of the feed rate of each tube is described in detail. The cost of this installation is much lower than that of belt conveyors and repairs and exchange of worn parts easily and quickly done, but they are easily clogged by wet coal, especially the polyester elbow between bunker outlet and tube. The life of the tubes is 8000–10,000 h.

Heat: Cycles and Transmission

A Review of Heat Transfer Literature 1960. Pt. 1. E. R. G. Eckert, T. F. Irvine, E. M. Sparrow and W. E. Ibele. *Mech. Engng.* 1961, **83** (July), 34–42.

The first part reviews literature dealing with conduction, channel flow, boundary layer flow, flow with separated regions, transfer mechanism and natural convection.

The Melchett Lecture for 1960. Radiative Transfer in Combustion Chambers. H. C. Hottel. *J. Inst. Fuel* 1961, **34** (June), 220–34.

A mathematical analysis of furnace gas radiation is presented. Both rigorous and simplified equations have been developed and their application is discussed. Using machine calculations the systems of simultaneous linear equations can be solved and the simplified equation tested against the rigorous treatment.

Thermal and Flow Investigations on Finned Tube Bundles in Cross Flow. Pt. II. Influence of Fin and Tube Arrangement. H. Brauer. *Chem. Ing. Tech.* 1961, **33** (May), 327–35 (June), 431–8 (*in German*).

Heat transfer on finned tubes is disturbed by unfavorable flow conditions in the corners between fin and tube. The influence of the number of tube rows on heat transfer and pressure drop was investigated; this showed that both decrease with increasing number of rows. The Re number of the flowing medium has a large effect only on the heat transfer coefficient.

Steam Generation and Power Production

Pressure Reduction of Water and Water-Steam Mixtures in Orifices. H. Friedrich and G. Vetter. *Energie* 1961, **13** (May), 201–7 (*in German*).

Tests on orifices of small diameter with subcooled and boiling water, water-steam mixtures and saturated steam are reported and compared with other published data. Formulas are developed for different conditions.

The Movement of an Individual Droplet during Atomization. H. Hauschildt. *Energie* 1961, **13** (May), 207–11 (*in German*).

The movement of an individual droplet has been studied for various Re numbers obtained in tests. It is shown that although the conditions in an atomized cloud are much more complicated some fundamental laws are equally valid for a single droplet and a cloud. The equations permit an investigation of the influence of initial velocity which is a function of the atomizing pressure, of the specific gravity and of the dynamic viscosity of the air on the movement of the droplet. An example is calculated.

Post-War Developments in British Water-Tube Boiler Design—V. K. R. Lenel. *Steam Engr.* 1961, **30** (July), 338–44.

The last part of this review surveys boiler auxiliaries such as drums and their internals, pulverizers, burners, superheaters, economizers, air preheaters and electrostatic precipitators.

The State of the Steam Generator Technique. Evaluation of the Boiler Index of the V.G.B. Pt. 5. H. Richter. *Mitt. V.G.B.* No. 72 1961 (June), 211–4 (*in German*).

The changes in the boiler statistics between 1957 and 1961 are tabulated and discussed. Total output increased by 22 per cent; the number of new natural circulation boilers installed is higher than those of forced-flow boilers, but the latter have the higher overall output. The forced-flow boiler is predominant above 125 t/h output. Although pulverized coal fired boilers constitute 81 per cent of the total output increase, the number of oil-fired boilers has more than doubled and 243 boilers were provided with additional oil firing. The installation of slagging furnaces is increasing still.

Circulation in Water-tube Boilers. T. Widell. *Tekn. Tidskr.* 1961, **91** (Mar. 17), 253–6 (*in Swedish*).

A new method of calculating the water circulation in the two new boilers for the Stenungsund power station, Sweden, based on a "working pressure efficiency," is described. Comparison between calculated results and measuring results is made in a further article.

From C.E.G.B. Digest 1961, **13** (June 10), 1669.

Measurement of Water Circulation in a Boiler. R. Carlson, B. Cederberg and K. Ljunggren. *Tekn. Tidskr.* 1961, **91** (Mar. 17), 257–62 (*in Swedish*).

Measurements of water circulation in the boiler for a 150 Mw set in the Stenungsund P/S, Sweden, are discussed. The methods used included current meters with radioactive cobalt and injection measurements with radioactive ammonium bromide. The measured results are compared with calculated results.

From C.E.G.B. Digest 1961, **13** (June 10), 1670.

Flow Resistances in the Heated Evaporator of a Benson Boiler. O. Schwarz. *Mitt. V.G.B.* No. 72 1961 (June), 143–55 (*in German*).

Measurements were carried out on a Benson boiler of the Hamburg Electricity Works to obtain an insight into the influence of volume and heat content of the flowing medium on the pressure drop coefficient of heated evaporator tubes and to compare these with those of unheated tubes. The highest values occurred at the start of evaporation and low flow rates caused by the formation of steam bubbles on the tube wall. The results should be useful for the control of forced-flow boilers.

Dynamic Behavior of Forced-Flow Evaporator Systems. P. Profos. *Sulzer Tech. Rev.* 1960, No. 4, 5–12.

A combined graphical and mathematical method has been developed by which the transfer characteristics can be determined from the design data of the boiler.

Calculation of the Dynamic Behavior of Heat Exchangers with the Aid of Analogue Computers. L. Acklin and F. Läubli. *Sulzer Tech. Rev.* 1960, No. 4, 13–21.

The development of the method and its application to the control of a superheater are described.

Simple Method of Calculation for the Steam Temperature Control of Boilers. G. Klefenz. *Mitt. V.G.B.* No. 72 1961 (June), 191–200 (*in German*).

The dynamic behavior of the final superheater is considered and equations are developed for the determination of the maximum control deviation using only data available in the design stage. A practical example shows the application of the equations.

Load Dependent Influence on Heat Exchange in Boilers by Heat Recirculation. K. Becker. *Energie* 1961, **13** (May), 212–8 (*in German*).

Possibilities of keeping the temperature of the superheated steam constant at all loads by flue gas recirculation from the furnace to the convection pass and vice versa, recirculation of steam or air from heat exchanger exit to its entry, by-passing of steam, air or feed water and their effect on overall efficiency and total cost are discussed. The advantages and disadvantages of each system or combination are outlined and equations developed with which an estimate of the results of the application of the different means can be obtained. It is shown that their application has different effects in natural and assisted circulation boilers and in forced flow boilers.

Damage to High-temperature Superheaters. R. Lemaire. *Bull. d'Inf. des Cent. Elect.* 1961 (Apr.), 13–15 (*in French*).

A brief account is given of damage arising in the Combustion Engineering boiler at Harnes power station after 56,000–60,000 hours' operation. Cracks developed on the internal walls of superheater tubes near the spacer weld and spread lengthwise following the generatrices, and depthwise to become transverse, attaining a length of 1½ inches. Micrographic examination revealed a wide area of ferrite grain enlargement caused by superficial decarburation, probably due to the high silicon content of the steel.

From C.E.G.B. Digest 1961, **13** (July 22), 2131.

Thermal Insulation Guarantees for Boiler Insulations. W. F. Cammerer and J. Achtziger. *Mitt. V.G.B.* No. 72 1961 (June), 180–91 (*in German*).

Theoretical considerations and experimental temperature and heat flow measurements on a boiler insulation have shown the unsuitability of the previously used guarantee quantities, i.e., heat loss of housing and its surface temperature. The measurements confirmed that the heat conductance coefficient unequivocally characterizes the boiler insulation and this quantity is now specified as the value to be guaranteed in the new V.G.B. specifications for boiler insulations. Details of the temperature and heat flow measuring methods used and results obtained on a 100 t/h cyclone fired boiler are given.

Larger Repairs on Boilers—Their Permissibility, Assessment and Testing. H. Höcker. *Tech. Überw.* 1961, 2 (July), 246–9 (*in German*).

Kinds of failure and their causes are tabulated for vertical, fire-tube, smoke-tube and water-tube boilers. The points to be considered in permitting or refusing repairs, assessment and testing of repairs carried out are discussed.

Chemical Cleaning of Boilers, Steam Turbines, Nuclear Reactors etc. E. A. Ulrich. *Energie* 1961, **13** (May), 231–5 (*in German*).

Some practical advice is given on the chemical cleaning of shell-type, sectional and vertical water-tube boilers, superheaters, steam turbines and nuclear reactors. Examples of successful cleaning are cited.

Furnaces and Combustion

Radiating Capacity of Furnace Installations. A. M. Gurvich and V. V. Mitor. *Teploenergetika* 1960 (Nov.), 66–9. D.S.I.R. Transl. RTS 1830.

New calculations are developed for the radiation in boiler furnaces taking into account that the tubes are practically always covered by fine ash particles offering high resistance to the passage of heat and causing an "intrinsic" radiation. Calculations are carried out on a fuel-bed type furnace with heat receiving surfaces uniformly distributed over all the walls.

Predicted Burning Times of Solid Particles in an Idealized Dust Flame. R. H. Essenhigh. *J. Inst. Fuel* 1961, **34** (June), 239–44.

Burning times have been calculated on the separate assumptions of reaction control by a diffusion film (square law) and by surface chemical reaction (linear law). By combining both factors simultaneously the two solutions are found to be additive. The significance of the findings and their effect on calculating burning times are discussed.

Refractory Arches and Walls. W. J. C. Shears. *Pwr. and Wrks. Engng.* 1961, **56** (July), 563–71.

Examples of recent installations in boiler and other furnaces are described.

Water-Side Corrosion and Water Treatment

Considerations Regarding Demineralization and Flash Evaporation of High-Pressure Boiler Makeup Water. M. E. Gilwood and J. G. Mack. *Amer. Pwr. Conf. Paper* 1961 (Mar.).

Comparison of demineralization versus flash evaporation in large high-pressure steam-generating plants is made on grounds of (1) Water quality; (2) Reliability; (3) Economics; (4) Labor; (5) Maintenance; (6) Corrosion—to name but a few. Economic comparison showed equipment-cost advantage for demineralizer with waters having over 1300 ppm total electrolytes (as $CaCO_3$). Total annual cost advantage for demineralizer starts at about 500 ppm total electrolytes—both figures based on 20,000 lb/hr unit capacity. Demineralizer's additional advantage: improved heat rate and availability of high-quality water for plant startup.

From C.E.G.B. Digest 1961, **13** (July 8).

The Effect on Water and Steam Quality of Colloidally Dispersed Particles. H. Kurapkat and E. Walther. *Mitt. V.G.B.* No. 72 1961 (June), 163–70 (*in German*).

Heavy silica deposits in a topping turbine were traced to a breakdown of the demineralizer beds after heavy rainfall in the neighborhood and consequent increased turbidity of the river water used for feed water make-up. Adsorption flocculation proved successful in preventing breakdown of the demineralizer beds but difficult to operate under varying loads. A provisional system of filter aids proved equally successful without the attending difficulties and a full-scale plant has been ordered. Details are given of measurements of suspended iron oxides, behavior of silica, measuring and determination of colloids, supervision of adsorption plants and the effect of reduction of colloids on the water-steam circuit.

Experimental Investigations of a Few Problems Arising in Once-Through Forced-Circulation Steam Generators Operating at Supercritical Pressures. J. Kägi. *Sulzer Tech. Rev.* 1961, **43**, No. 1, 29–35.

Studies of salt deposition in tubes of supercritical pressure boilers at temperatures up to 1200 F are reported which gave some unexpected results. Salt deposition occurred although the salt concentration in the feed water was far below the maximum solubility level and the deposits remained stable only at certain temperatures. Lowering of the temperature caused existing deposits to vanish in a short time. Various alkalizing agents were tried of which only ammonia remained stable at 1200 F.

The Solubility of Silicic Acid in Steam. R. Feitsma. *Mitt. V.G.B.* No. 72 1961 (June), 170–6 (*in German*).

On the basis of equations and data published by various authors' new formulas for the distribution coefficient of silicic acid in water and saturated steam and its solubility in

superheated steam have been deduced and two diagrams constructed. Their validity will be checked experimentally.

The Examination of Oxide Scales on Iron-Chromium Alloys by X-ray Scanning Microanalysis. G. C. Wood and D. A. Melford. *J. Iron and Steel Inst.* 1961, **198** (June), 142–8.

Oxide scales on iron-chromium alloys in steam at 950–1000 C were examined by X-rays and two major scale layers were found, the outer one consisting of Wüstite and the inner one of a complex distribution of oxides of iron and chromium. Chromium depletion in the alloy next to the alloy/scale interface has been observed.

Flue Gas, Ash and Dust

Cold Corrosion in Oil-Fired Boilers. Various Authors. *Schweiz. Arch.* 1961, **27** (May), 180–220 (*in German*).

The papers presented at a Swiss Conference held at Zürich on September 16, 1960, are published as follows: (1) Physicochemical Considerations of the Gas-Side Corrosion in Boiler Operation, by A. Bukowiecki; (2) Prevention of Corrosion and Deposits in Boilers Fired by Fuel Oil of High S Content, by E. Zehnder; (3) Problems of Corrosion, Deposit Formation and Air Pollution in Oil-Fired Boilers, by J. Greenwood and G. R. Wade; (4) Design Measures for the Prevention of Low-Temperature Corrosion in Oil-Fired Boiler Plants, by G. Peter; (5) Discussion.

The Influence of Dolomite on Acid Dew Point and Low-Temperature Corrosion in Oil-Fired Boilers. H. Draaijer and H. J. Pel. *B.W.K.* 1961, **13** (June), 266–9 (*in German*).

Measurements on two oil-fired boilers of acid dew point by the Degussa dew point meter and economizer tube surface temperature by resistance thermometer with and without dolomite addition are reported. It is stressed that dolomite does not reduce the acid dew point but reduces corrosion on certain points but not throughout the boiler. Despite regular soot blowing with steam heavy deposits formed necessitating thorough cleaning after 1500 h. Reduction of corrosion by increasing the feed water inlet temperature is recommended so that the wall temperature of the economizer tubes is above the acid dew point.

Thermal Insulation for Steel Chimneys. J. D. Blakeley. *Pwr. Wrks. Engng.* 1961, **56** (July), 551–4.

Protection of steel chimneys against erosion and corrosion is discussed and the various methods in use compared.

The recently developed use of an outer shield of bright aluminium sheet spaced away from the chimney proper appears to be the best solution in preventing corrosion and emission of sticky smut deposits.

Baghouse Cures Stack Effluent. C. O'Connor and G. Swinehart. *Pwr. Engng.* 1961, **65** (May), 58–9.

To meet air pollution regulations a baghouse filter plant was added to the Pasadena incinerator installation. The filter bags made of silicon treated fibreglass with a permeability of 81, filter velocity of 5 fpm, pressure drop of 3–5 in. w.g. and flue gas flow of 375 cfm reduce the dust content from 13.4 gr/ft³ to 0.031 gr/ft³, an efficiency of 99.77 per cent. The filtered flue gas contains 1.6 ppm SO_3, the unfiltered flue gas 27.3 ppm SO_3. Despite flue gas temperatures of up to 750 F no deterioration of the bag material has been observed.

Effect of Tube Spacing and Arrangement upon the Fouling Characteristics of Banks of Tubes. P. Profos and H. N. Sharan. *Sulzer Tech. Rev.* 1960, No. 4, 31–43.

Tests are described which enabled obtaining mathematical data relating to the effect of pipe geometry on the fouling of tube banks. In-line banks have a smaller relative fouling tendency than staggered spacings and generally give higher heat transfer coefficients.

Power Generation and Power Plant

Generating Plant Design. C. W. Priest. *Elect. Rev.* 1961, **168** (June 9), 1005–8.

A review of the increase in size of power stations, boilers and turbo-generators since 1920 to match the increase in the annual consumption of electricity per head of population of 90 kwhr in 1920 to 1900 kwhr in 1960. Increase in size beyond the 500 Mw single-line units just ordered for commissioning in 1965 is possible, especially if two-line sets were adopted, but an early decision is not expected.

Condensing Power Stations in Russia. B. v. Gersdorff. *Elektwirtsch.* 1961, **60** (June 20), 414–23 (*in German*).

A summary of recently published Russian literature on the planning of power stations for the period 1959/1965 is presented. Eight standardized power stations of 1200 Mw with 6 × 200 Mw units and 640 t/h boilers are being built, and 22 power stations of 2400 Mw output with 8 × 300 Mw and boilers of 950 t/h are to be built. Their main characteristic is the central pulverizing plant outside the actual power station and the use of intermediary bunkers between boilers

with a 2 h reserve. The mills are generally of the ball type and have capacities of 50 t/h. The steam parameters for the smaller stations are 140 atü, 570/565 C, those for the larger stations 250 atü and 585/565 C. It is also planned to build 18 out-of-door stations of 600 Mw capacity with 4 × 150 Mw units and boilers rated at 500 t/h at 140 atü and 570/565 C.

Power Industry's Leaders Exchange Information at American Power Conference. Anon. *Pwr. Engng.* 1961, **65** (May), 45–8, 82, 84.

The papers presented at the 1961 American Power Conference are summarized: (1) Transmission, distribution; (2) Nuclear power development; (3) Central stations (Avon and Breed plants); (4) Paradise plant; (5) Combined cycle; (6) Binary cycle; (7) Boiler feed pumps; (8) Electrical apparatus; (9) Automation and control; (10) Fuels; (11) Water; (12) Industrial plants; (13) Flue gas sampling; (14) Peaking symposium; (15) Air pollution.

Study of Double Reheat. H. Beyerlein and H. Mitschel. *B.W.K.* 1961, **13** (July), 320–6 (*in German*).

Fifteen different variations of a 200 Mw unit with steam parameters, preheater stages and number of reheats as variables were compared with a basic unit employing steam at 2560 psi and 1005/1005° F. The savings in fuel are in most variations negatived by increased capital costs and payment of interests on the excess capital used. A nomogram has been developed as a basis for diagrams by which the calculation of the optimum design for given local conditions is facilitated.

The Theory of Combined Steam and Gas Turbine Installations. C. Seippel and P. Bereuter. *Brown Boveri Rev.* 1960, **47** (Dec.), 783–99.

A comprehensive and unbiased survey of the combinations worth considering is presented and the basic thermodynamic relationships are derived. Thermal efficiency, capital costs, safety, ease of control, fuel properties, running hours are also considered. The economics of a typical example are investigated.

Practical Examples of Utilizing the Waste Heat of Gas Turbines in Combined Installations. W. P. Auer. *Brown Boveri Rev.* 1960, **47** (Dec.), 800–25.

Four stations, Korneuburg, Cornigliano steelworks, Dudelange steelworks and Vahr district-heating stations, with different combinations of gas and steam turbines are described. Results of acceptance tests are tabulated.

One Prime Contract-One 350-Mw Plant Installed. H. R. Drew. *Pwr. Engng.* 1961, **65** (May), 70–1.

The 350 Mw addition at the Handley station of Texas Electric Service Co. has been awarded under a turnkey contract to Westinghouse and will consist of a pressurized furnace outdoor boiler rated at 2486 klb/hr at 2465 psi and 1005/1005 F fired by natural gas or oil as standby with provision for conversion to solid fuel firing and an outdoor tandem compound four-flow turbo-generator with 7 extraction stages. The full capacity boiler feed pumps will be driven via a hydraulic coupling from the turbine end of the shaft. The net heat rate is expected to be 7892 Btu/kwh and the total costs less than $80/kw.

Ptolemais Greece's Largest Brown Coal Power Station. T. Geissler. *Energie* 1961, **13** (June), 254–62 (*in German*).

Ptolemais Power Station in Greece. C. Koch and W. Stamm. *Brown Boveri Rev.* 1960, **47** (Dec.), 826–44.

The former article deals mainly with the characteristics of the brown coals, the design of the boiler and its auxiliaries, the latter article mainly with the electrical installations. The boiler is rated at 625 klb/h at 1260 psi and 955 F with natural circulation and corner burners supplemented by oil burners for ignition and low load operation. The brown coal has a moisture content of up to 60 per cent, ash content of up to 24 per cent and a gross C.V. from 2000 to 2400 Btu/lb.

Otto de Lorenzi Accorded Honor

Otto de Lorenzi, formerly educational director of Combustion Engineering, Inc., was given the Percy Nicholls Award at the Solid Fuels Conference of the ASME at Birmingham, Ala., on October 5, 1961.

In granting the award Julian Tobey, consulting engineer, cited these commendable facts about Mr. de Lorenzi:

"His patient studies led to the development of a technique for producing colored motion pictures that permitted the recording of actual furnace operating conditions with various types of fuel burning equipment using many different fuels.

"His comprehensive and authoritative reference text, *Combustion Engineering*, served greatly in the dissemination of new techniques and practices in fuel burning throughout the world.

"Moreover, his manifold services to the engineering societies, his many papers and articles greatly enhanced the role of the societies and the technical press in furthering the overall knowledge of his fellow engineers."

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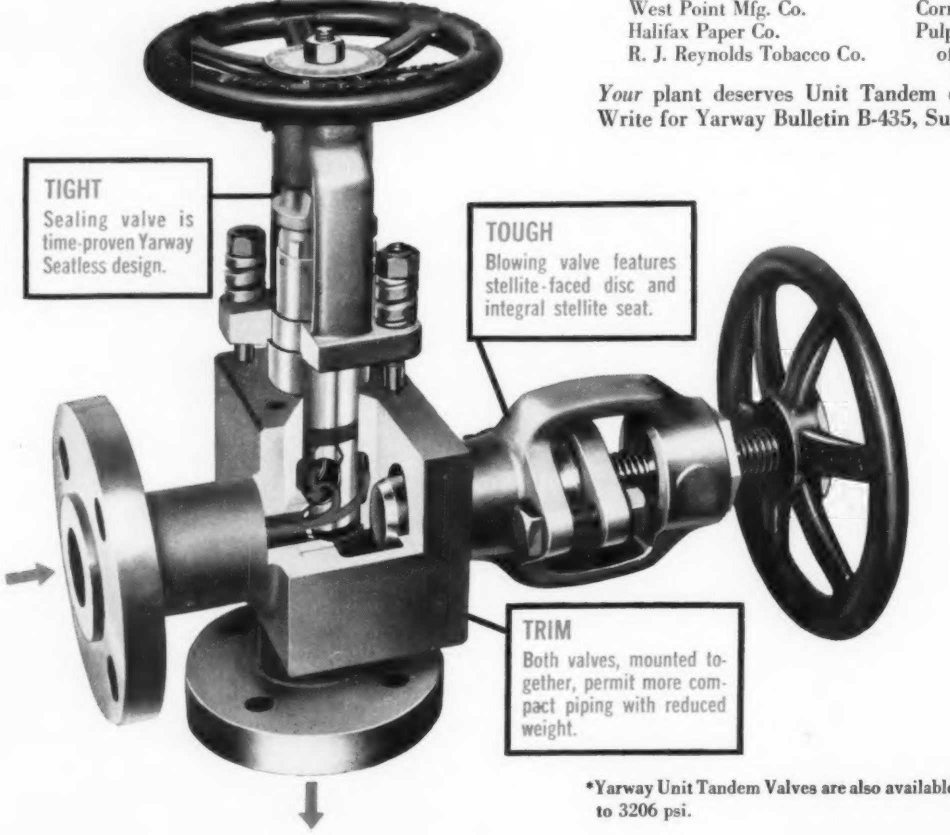

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